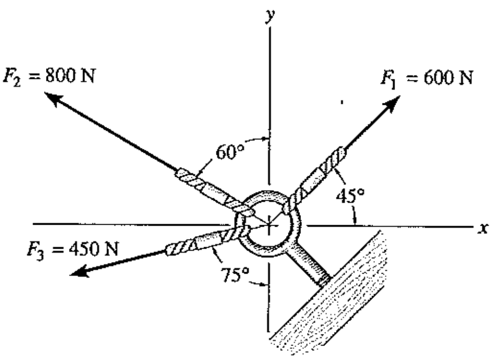
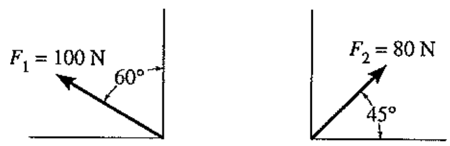
PROBLEMS

2-1. Determine the magnitude of the resultant force $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$ and its direction, measured counterclockwise from the positive x axis.



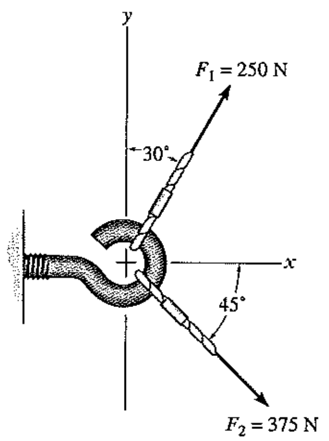
Prob. 2–1

2-2. Determine the magnitude of the resultant force if: (a) $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$; (b) $\mathbf{F}'_R = \mathbf{F}_1 - \mathbf{F}_2$.



Prob. 2–2

2-3. Determine the magnitude of the resultant force $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$ and its direction, measured counterclockwise from the positive x axis.

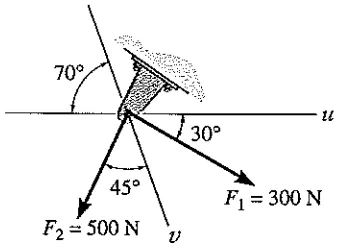


Prob. 2–3

***2-4.** Determine the magnitude of the resultant force $\mathbf{F}_R = \mathbf{F}_1 + \mathbf{F}_2$ and its direction, measured clockwise from the positive u axis.

2-5. Resolve the force $\mathbf{F}_1$ into components acting along the u and v axes and determine the magnitudes of the components.

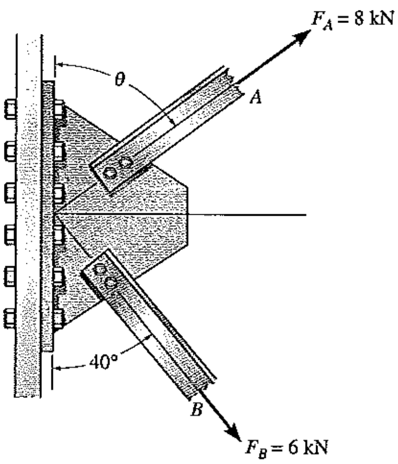
2-6. Resolve the force $\mathbf{F}_2$ into components acting along the u and v axes and determine the magnitudes of the components.



Probs. 2–4/5/6

2-7. The plate is subjected to the two forces at A and B as shown. If $\theta = 60°$, determine the magnitude of the resultant of these two forces and its direction measured from the horizontal.

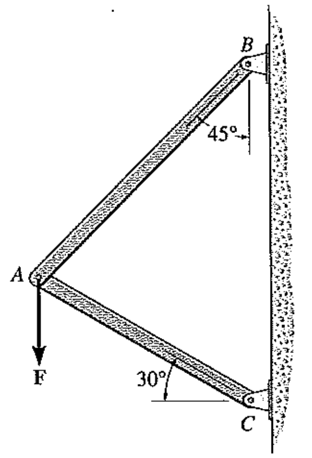
***2-8.** Determine the angle θ for connecting member A to the plate so that the resultant force of F_A and F_B is directed horizontally to the right. Also, what is the magnitude of the resultant force.



Probs. 2–7/8

2-9. The vertical force **F** acts downward at A on the two-membered frame. Determine the magnitudes of the two components of **F** directed along the axes of AB and AC. Set $F = 500$ N.

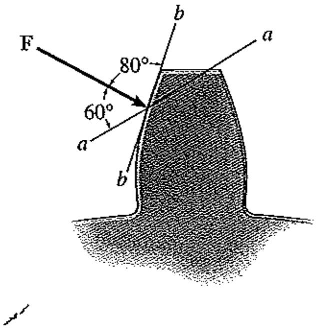
2-10. Solve Prob. 2–9 with $F = 350$ N.



Probs. 2–9/10

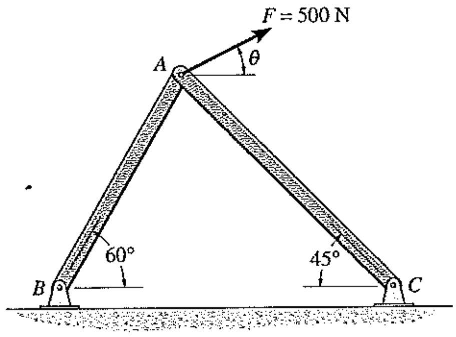
2-11. The force acting on the gear tooth is $F = 20$ N. Resolve this force into two components acting along the lines *aa* and *bb*.

***2-12.** The component of force **F** acting along line *aa* is require to be 30 N. Determine the magnitude of **F** and its component along line *bb*.



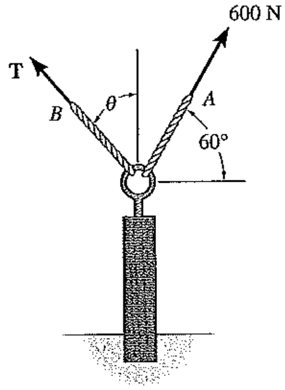
Probs. 2–11/12

2-13. The 500-N force acting on the frame is to be resolved into two components acting along the axis of the struts AB and AC. If the component of force along AC is required to be 300 N, directed from A to C, determine the magnitude of force acting along AB and the angle θ of the 500-N force.



Prob. 2–13

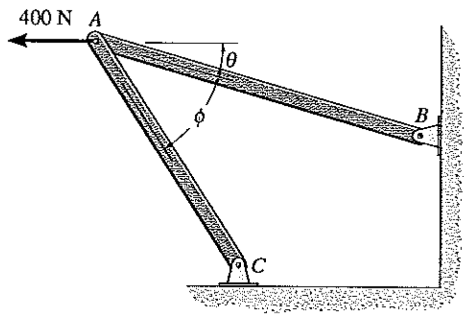
2-14. The post is to be pulled out of the ground using two ropes A and B. Rope A is subjected to a force of 600 N and is directed at 60° from the horizontal. If the resultant force acting on the post is to be 1200 N, vertically upward, determine the force T in rope B and the corresponding angle θ.



Prob. 2–14

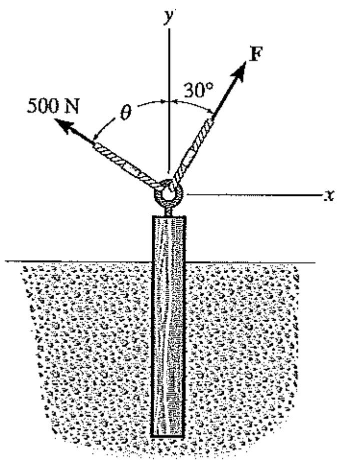
2-15. Determine the design angle $\theta(0^\circ \leq \theta \leq 90^\circ)$ for strut AB so that the 400-N horizontal force has a component of 500-N directed from A towards C. What is the component of force acting along member AB? Take $\phi = 40^\circ$.

***2-16.** Determine the design angle $\phi(0^\circ \leq \phi \leq 90^\circ)$ between struts AB and AC so that the 400-N horizontal force has a component of 600-N which acts up to the left, in the same direction as from B towards A. Take $\theta = 30^\circ$.



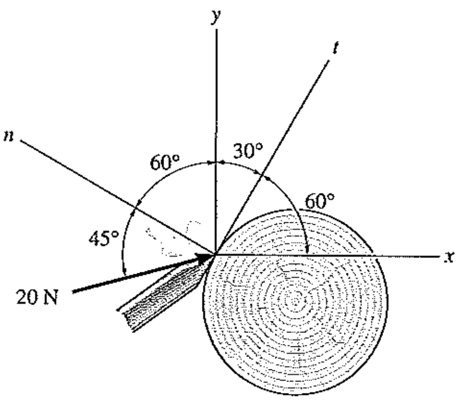
Probs. 2–15/16

2-18. Two forces are applied at the end of a screw eye in order to remove the post. Determine the angle θ $(0^\circ \leq \theta \leq 90^\circ)$ and the magnitude of force **F** so that the resultant force acting on the post is directed vertically upward and has a magnitude of 750 N.



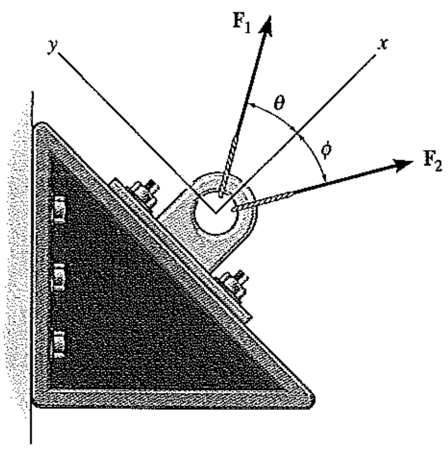
Prob. 2–18

2-17. The chisel exerts a force of 200 N on the wood dowel rod which is turning in a lathe. Resolve this force into components acting (a) along the n and t axes and (b) along the x and y axes.



Prob. 2–17

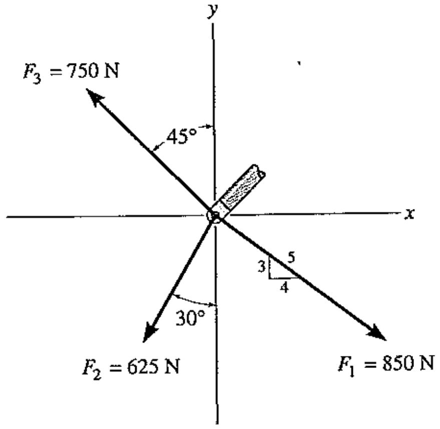
2-19. If $F_1 = F_2 = 300$ N determine the angles θ and ϕ so that the resultant force is directed along the positive x axis and has a magnitude of $F_R = 200$ N.



Prob. 2–19

PROBLEMS

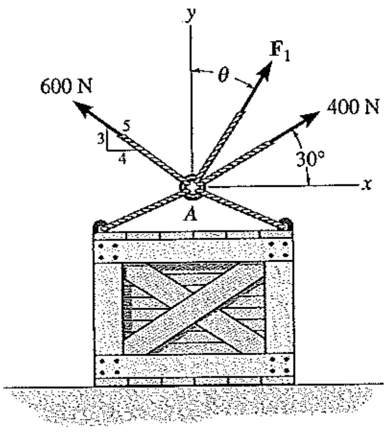
*2-20. Determine the magnitude of the resultant force and its direction, measured counterclockwise from the positive x axis.



Prob. 2–20

2-21. Determine the magnitude and direction θ of $\mathbf{F}_1$ so that the resultant force is directed vertically upward and has a magnitude of 800 N.

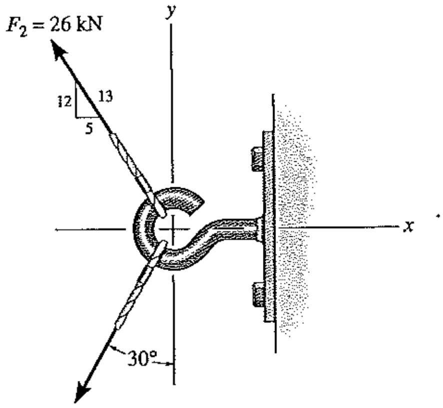
2-22. Determine the magnitude and direction measured counterclockwise from the positive x axis of the resultant force of the three forces acting on the ring A. Take $F_1 = 500$ N and $\theta = 20°$.



Prob. 2–22

2-23. Express $\mathbf{F}_1$ and $\mathbf{F}_2$ as Cartesian vectors.

*2-24. Determine the magnitude of the resultant force and its direction measured counterclockwise from the positive x axis.



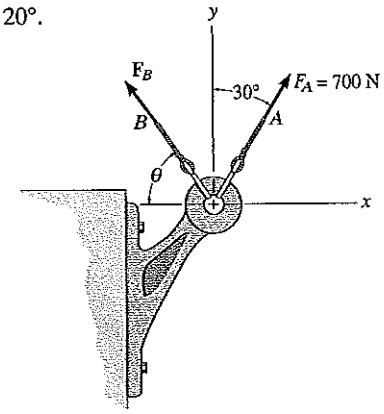
Probs. 2–23/24

2-25. Solve Prob. 2–1 by summing the rectangular or x, y components of the forces to obtain the resultant force.

2-26. Solve Prob. 2–22 by summing the rectangular or x, y components of the forces to obtain the resultant force.

2-27. Determine the magnitude and orientation θ of $\mathbf{F}_B$ so that the resultant force is directed along the positive y axis and has a magnitude of 1500 N.

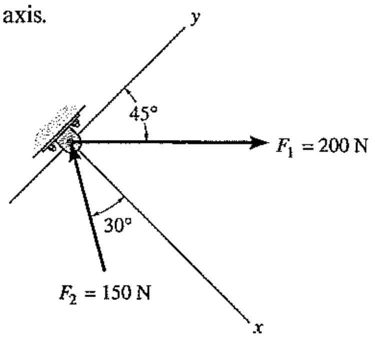
*2-28. Determine the magnitude and orientation, measured counterclockwise from the positive y axis, of the resultant force acting on the bracket, if $F_B = 600$ N and $\theta = 20°$.



Probs. 2–27/28

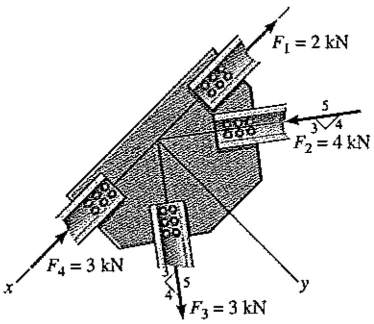
2-29. Determine the x and y components of $\mathbf{F}_1$ and $\mathbf{F}_2$.

2-30. Determine the magnitude of the resultant force and its direction, measured counterclockwise from the positive x axis.



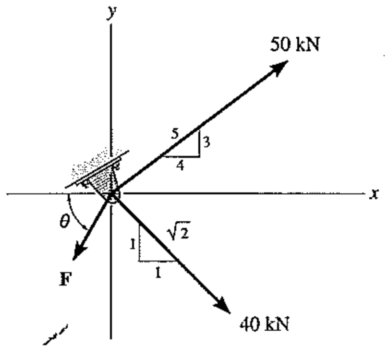
Probs. 2–29/30

2-31. Determine the x and y components of each force acting on the *gusset plate* of the bridge truss. Show that the resultant force is zero.



Prob. 2–31

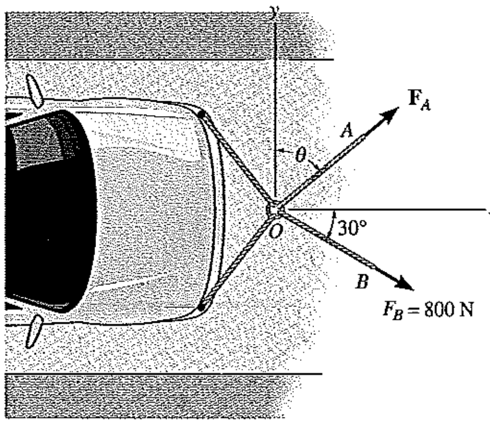
***2-32.** If $\theta = 60°$ and $F = 20$ kN, determine the magnitude of the resultant force and its direction measured clockwise from the positive x axis.



Prob. 2–32

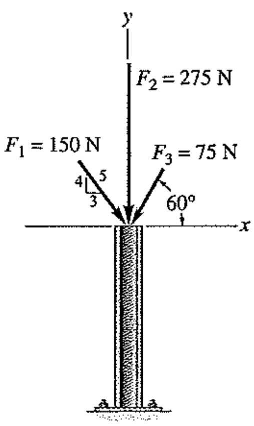
2-33. Determine the magnitude and direction θ of $\mathbf{F}_A$ so that the resultant force is directed along the positive x axis and has a magnitude of 1250 N.

2-34. Determine the magnitude and direction, measured counterclockwise from the positive x axis, of the resultant force acting on the ring at O, if $F_A = 750$ N and $\theta = 45°$.



Probs. 2–33/34

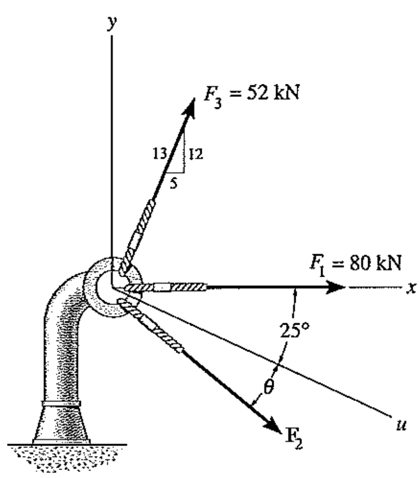
2-35. Express each of the three forces acting on the column in Cartesian vector form and compute the magnitude of the resultant force.



Prob. 2–35

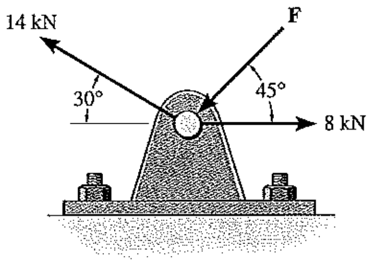
*2-36. Three forces act on the bracket. Determine the magnitude and orientation θ of $\mathbf{F}_2$ so that the resultant force is directed along the positive u axis and has a magnitude of 50 kN.

2-37. If $F_2 = 150$ kN and $\theta = 55°$, determine the magnitude and orientation, measured clockwise from the positive x axis, of the resultant force of the three forces acting on the bracket.



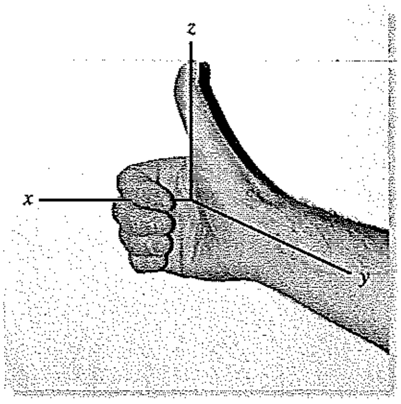
Probs. 2–36/37

2-38. Determine the magnitude of force $\mathbf{F}$ so that the resultant force of the three forces is as small as possible. What is the magnitude of the resultant force?



Prob. 2–38

2.5 Cartesian Vectors



Right-handed coordinate system.

Fig. 2–20

The operations of vector algebra, when applied to solving problems in *three dimensions*, are greatly simplified if the vectors are first represented in Cartesian vector form. In this section we will present a general method for doing this; then in the next section we will apply this method to solving problems involving the addition of forces. Similar applications will be illustrated for the position and moment vectors given in later sections of the book.

Right-Handed Coordinate System. A right-handed coordinate system will be used for developing the theory of vector algebra that follows. A rectangular or Cartesian coordinate system is said to be *right-handed* provided the thumb of the right hand points in the direction of the positive z axis when the right-hand fingers are curled about this axis and directed from the positive x toward the positive y axis, Fig. 2–20. Furthermore, according to this rule, the z axis for a two-dimensional problem as in Fig. 2–19 would be directed outward, perpendicular to the page.

ROBLEMS

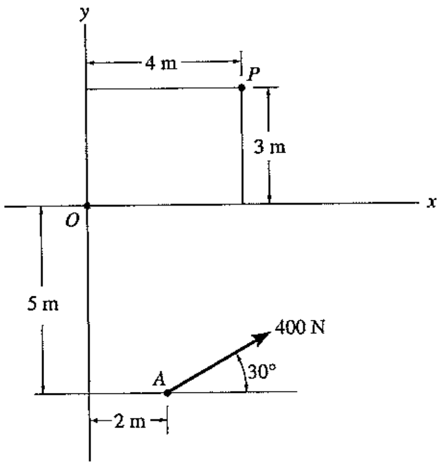
3-1. If **A**, **B**, and **D** are given vectors, prove the distributive law for the vector cross product, i.e., $\mathbf{A} \times (\mathbf{B} + \mathbf{D}) = (\mathbf{A} \times \mathbf{B}) + (\mathbf{A} \times \mathbf{D})$.

3-2. Prove the triple scalar product identity $\mathbf{A} \cdot (\mathbf{B} \times \mathbf{C}) = (\mathbf{A} \times \mathbf{B}) \cdot \mathbf{C}$.

3-3. Given the three nonzero vectors **A**, **B**, and **C**, show that if $\mathbf{A} \cdot (\mathbf{B} \times \mathbf{C}) = 0$, the three vectors *must* lie in the same plane.

***3-4.** Determine the magnitude and directional sense of the moment of the force at A about point O.

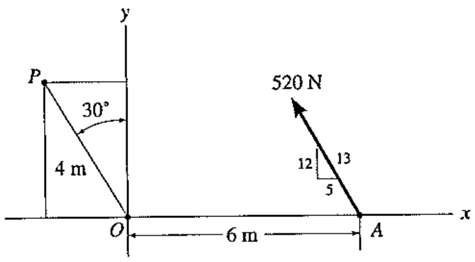
3-5. Determine the magnitude and directional sense of the moment of the force at A about point P.



Probs. 3–4/5

3-6. Determine the magnitude and directional sense of the moment of the force at A about point O.

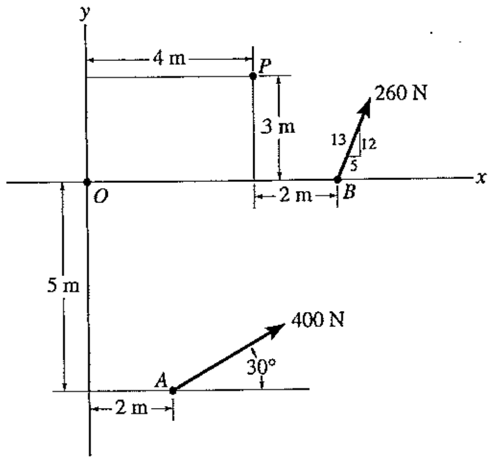
3-7. Determine the magnitude and directional sense of the moment of the force at A about point P.



Probs. 3–6/7

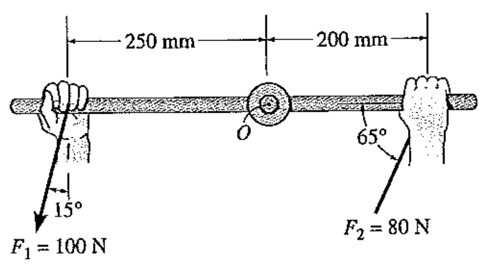
***3-8.** Determine the magnitude and directional sense of the resultant moment of the forces about point O.

3-9. Determine the magnitude and directional sense of the resultant moment of the forces about point P.



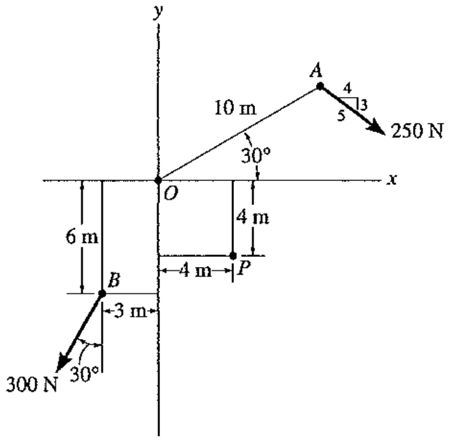
Probs. 3–8/9

3-10. The wrench is used to loosen the bolt. Determine the moment of each force about the bolt's axis passing through point O.



Prob. 3–10

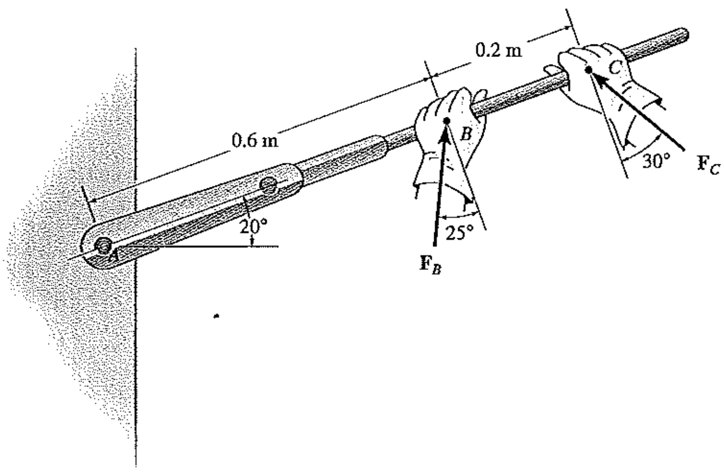
3-11. Determine the magnitude and directional sense of the resultant moment of the forces about point O.



Prob. 3–11

3-14. Determine the moment of each force about the bolt located at A. Take $F_B = 200$ N, $F_C = 250$ N.

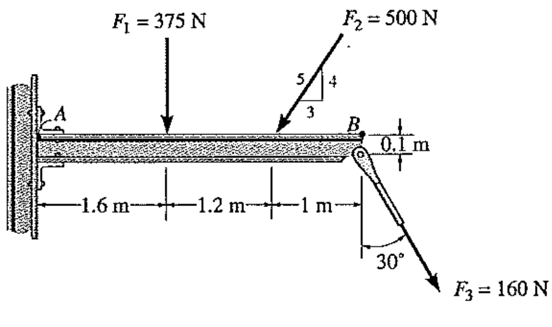
3-15. If $F_B = 150$ N and $F_C = 225$ N, determine the resultant moment about the bolt located at A.



Probs. 3–14/15

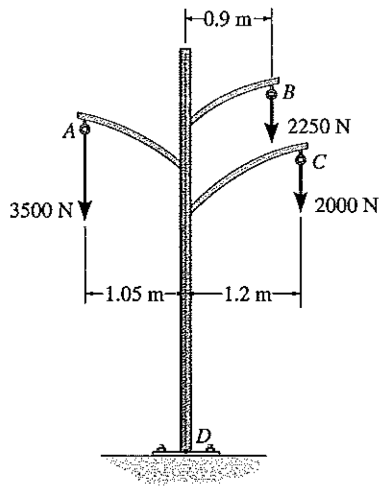
***3-12.** Determine the moment about point A of each of the three forces acting on the beam.

3-13. Determine the moment about point B of each of the three forces acting on the beam.



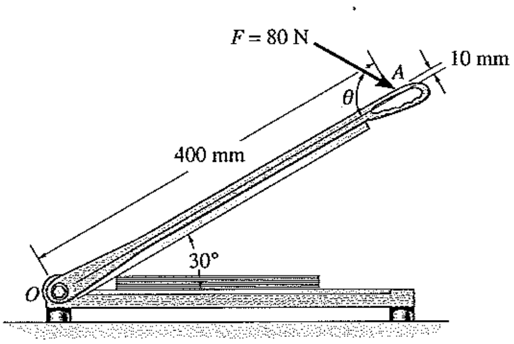
Probs. 3–12/13

***3-16.** The power pole supports the three lines, each line exerting a vertical force on the pole due to its weight as shown. Determine the resultant moment at the base D due to all of these forces. If it is possible for wind or ice to snap the lines, determine which line(s) when removed create(s) a condition for the greatest moment about the base. What is this resultant moment?



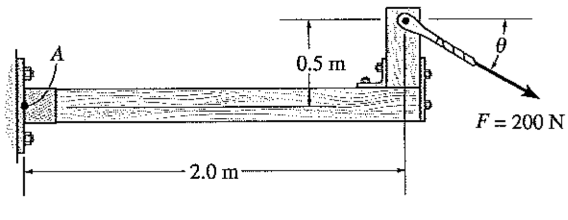
Prob. 3–16

3-17. A force of 80 N acts on the handle of the paper cutter at A. Determine the moment created by this force about the hinge at O, if $\theta = 60°$. At what angle θ should the force be applied so that the moment it creates about point O is a maximum (clockwise)? What is this maximum moment?



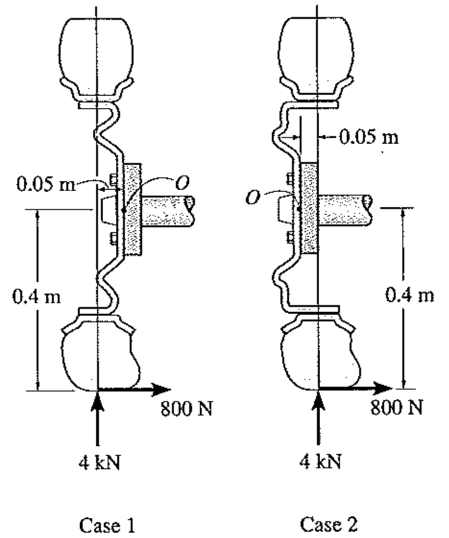
Prob. 3–17

3-18. Determine the direction $\theta (0° \leq \theta \leq 180°)$ of the force $F = 200$ N so that it produces (a) the maximum moment about point A and (b) the minimum moment about point A. Compute the moment in each case.



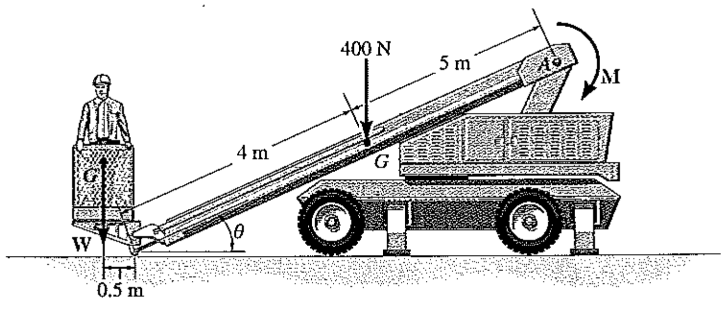
Prob. 3–18

3-19. The hub of the wheel can be attached to the axle either with negative offset (left) or with positive offset (right). If the tire is subjected to both a normal and radial load as shown, determine the resultant moment of these loads about the axle, point O for both cases.



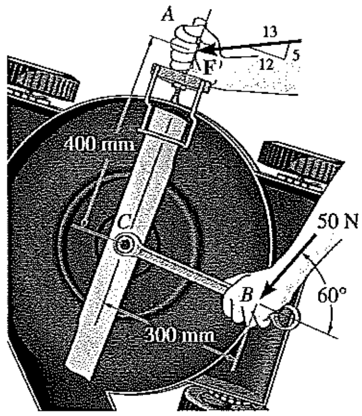
Prob. 3–19

***3-20.** The boom has a length of 9 m, a weight of 4000 N, and mass center at G. If the maximum moment that can be developed by the motor at A is $M = 30(10^3)$ N · m, determine the maximum load W, having a mass center at G', that can be lifted. Take $\theta = 30°$.



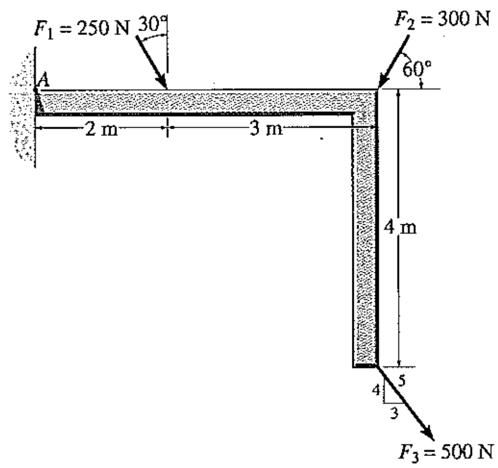
Prob. 3–20

3-21. The tool at A is used to hold a power lawnmower blade stationary while the nut is being loosened with the wrench. If a force of 50 N is applied to the wrench at B in the direction shown, determine the moment it creates about the nut at C. What is the magnitude of force $\mathbf{F}$ at A so that it creates the opposite moment about C?



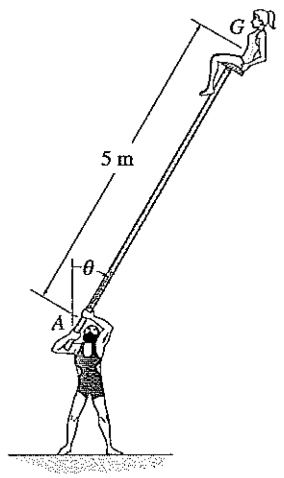
Prob. 3–21

3-22. Determine the moment of each of the three forces about point A. Solve the problem first by using each force as a whole, and then by using the principle of moments.



Prob. 3–22

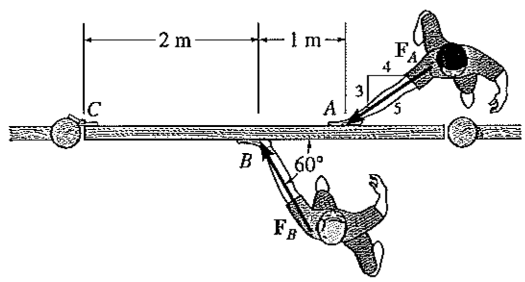
3-23. As part of an acrobatic stunt, a man supports a girl who has a weight of 500 N ($\approx$ 50 kg) and is seated on a chair on top of the pole. If her center of gravity is at G, and if the maximum counterclockwise moment the man can exert on the pole at A is 350 N · m, determine the maximum angle of tilt, θ, which will not allow the girl to fall, i.e., so her clockwise moment about A does not exceed 350 N · m.



Prob. 3–23

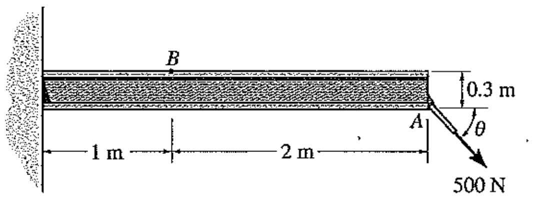
***3-24.** The two boys push on the gate with forces of $F_A = 120$ N and $F_B = 200$ N as shown. Determine the moment of each force about C. Which way will the gate rotate, clockwise or counterclockwise? Neglect the thickness of the gate.

3-25. Two boys push on the gate as shown. If the boy at B exerts a force of $F_B = 120$ N, determine the magnitude of the force F_A the boy at A must exert in order to prevent the gate from turning. Neglect the thickness of the gate.



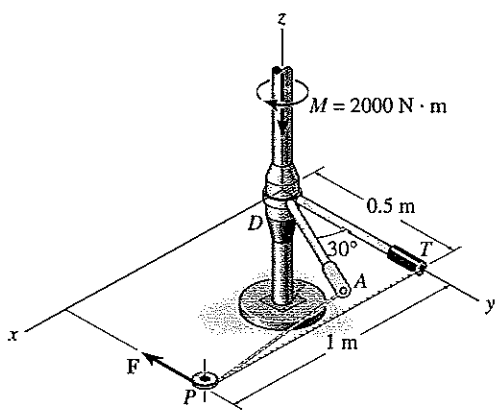
Probs. 3–24/25

*3-26. Determine the angle θ at which the 500-N force must act at A so that the moment of this force about point B is equal to zero.



Prob. 3–26

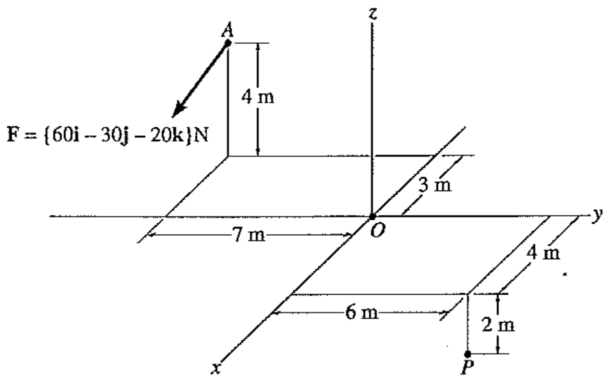
3-27. Segments of drill pipe D for an oil well are tightened a prescribed amount by using a set of tongs T, which grip the pipe, and a hydraulic cylinder (not shown) to regulate the force **F** applied to the tongs. This force acts along the cable which passes around the small pulley P. If the cable is originally perpendicular to the tongs as shown, determine the magnitude of force **F** which must be applied so that the moment about the pipe is $M = 2000\ \text{N} \cdot \text{m}$. In order to maintain this same moment what magnitude of **F** is required when the tongs rotate 30° to the dashed position? *Note:* The angle DAP is not 90° in this position.



Prob. 3–37

3-28. Determine the moment of the force at A about point O. Express the result as a Cartesian vector.

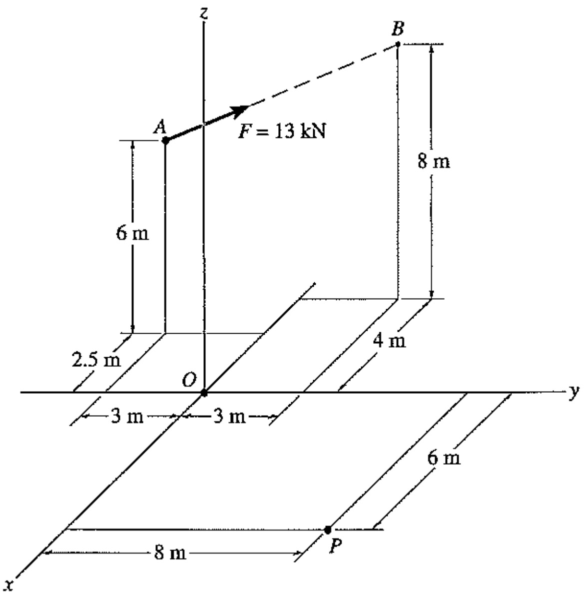
3-29. Determine the moment of the force at A about point P. Express the result as a Cartesian vector.



Probs. 3–28/29

*3-30. Determine the moment of the force **F** at A about point O. Express the result as a Cartesian vector.

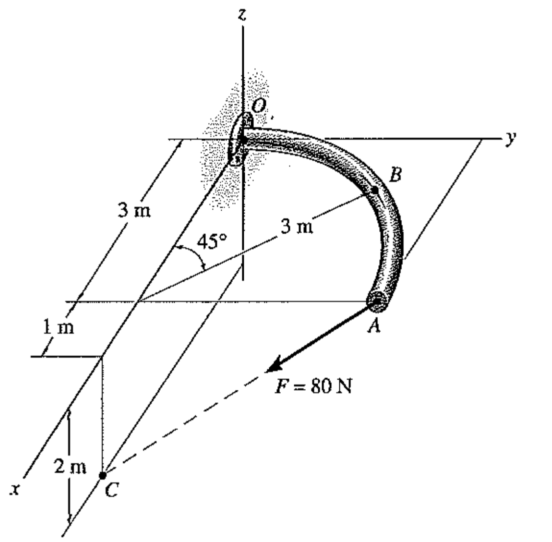
3-31. Determine the moment of the force **F** at A about point P. Express the result as a Cartesian vector.



Probs. 3–30/31

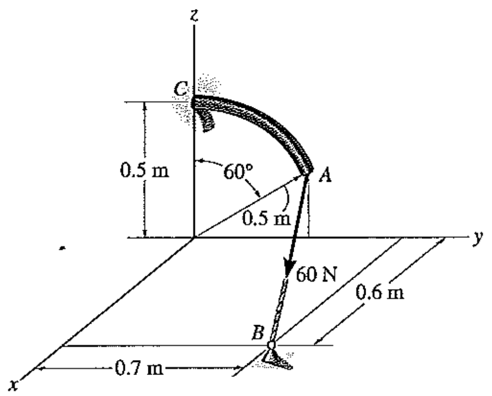
3-32. The curved rod lies in the x-y plane and has a radius of 3 m. If a force of $F = 80$ N acts at its end as shown, determine the moment of this force about point O.

3-33. The curved rod lies in the x-y plane and has a radius of 3 m. If a force of $F = 80$ N acts at its end as shown, determine the moment of this force about point B.



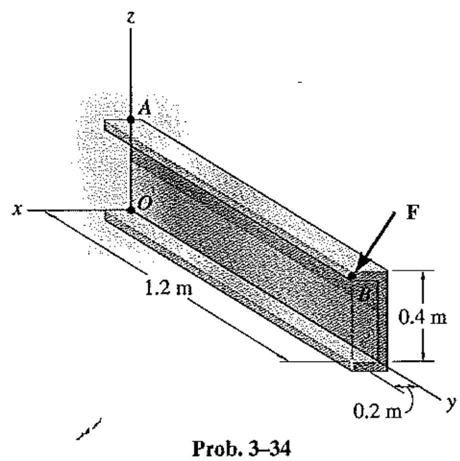
Probs. 3–32/33

3-35. The curved rod has a radius of 0.5 m. If a force of 60 N acts at its end as shown, determine the moment of this force about point C.



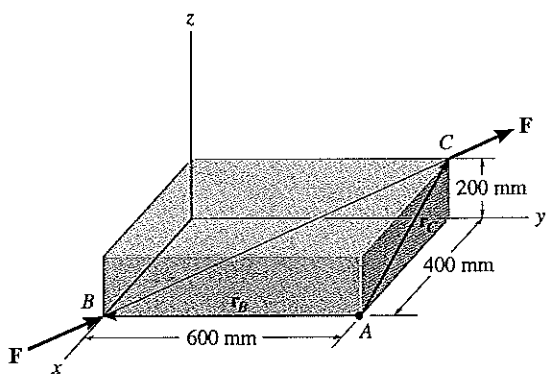
Prob. 3–35

***3-34.** The force $\mathbf{F} = \{600\mathbf{i} + 300\mathbf{j} - 600\mathbf{k}\}$ N acts at the end of the beam. Determine the moment of the force about point A.



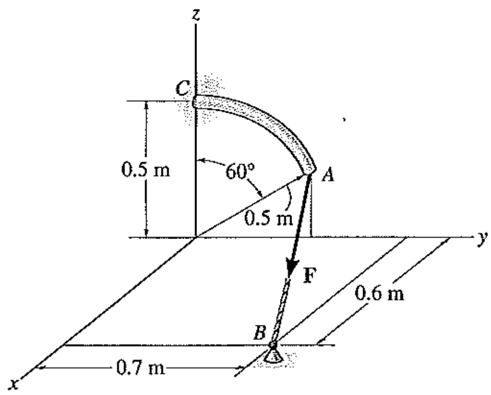
Prob. 3–34

3-36. A force $\mathbf{F}$ having a magnitude of $F = 100$ N acts along the diagonal of the parallelepiped. Determine the moment of $\mathbf{F}$ about point A, using $\mathbf{M}_A = \mathbf{r}_B \times \mathbf{F}$ and $\mathbf{M}_A = \mathbf{r}_C \times \mathbf{F}$.



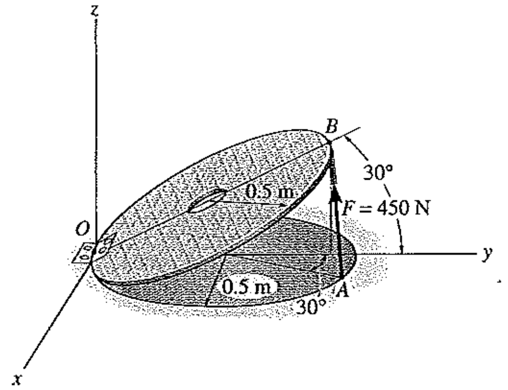
Prob. 3–36

3-37. Determine the smallest force F that must be applied along the rope in order to cause the curved rod, which has a radius of 0.5 m, to fail at the support C. This requires a moment of $M = 80\ \text{N} \cdot \text{m}$ to be developed at C.



Prob. 3–37

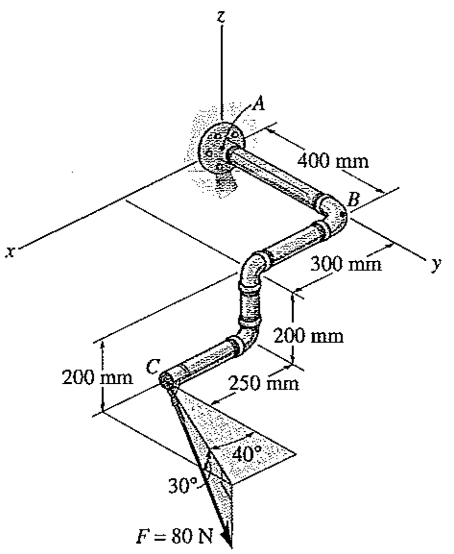
3-40. Strut AB of the 1-m-diameter hatch door exerts a force of 450 N on point B. Determine the moment of this force about point O.



Prob. 3–40

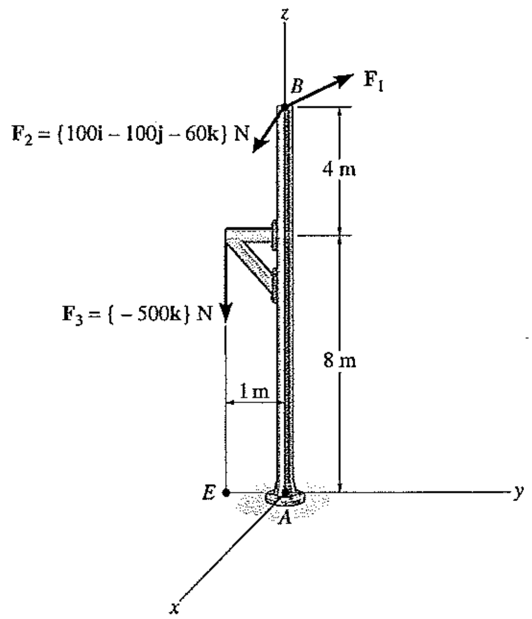
***3-38.** The pipe assembly is subjected to the 80-N force. Determine the moment of this force about point A.

3-39. The pipe assembly is subjected to the 80-N force. Determine the moment of this force about point B.



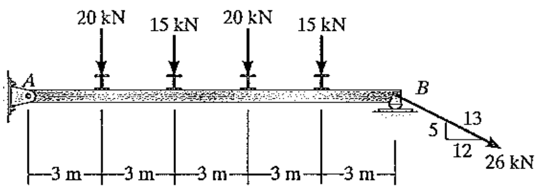
Probs. 3–38/39

3-41. Using Cartesian vector analysis, determine the resultant moment of the three forces about the base of the column at A. Take $\mathbf{F}_1 = \{400\mathbf{i} + 300\mathbf{j} + 120\mathbf{k}\}$ N.



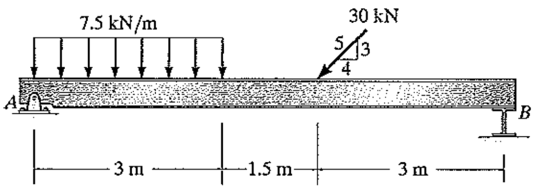
Prob. 3–41

2-17. Determine the reactions on the beam.



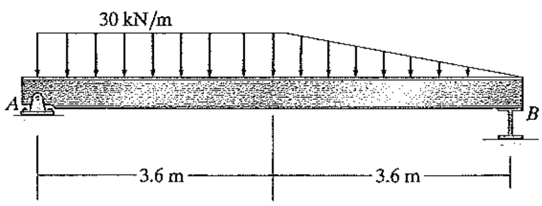
Prob. 2–17

2-18. Determine the reactions on the beam. The support at B can be assumed as a roller.



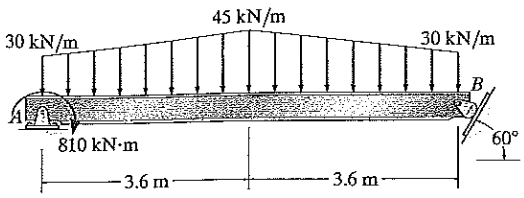
Prob. 2–18

2-19. Determine the reactions on the beam. The support at B can be assumed to be a roller.



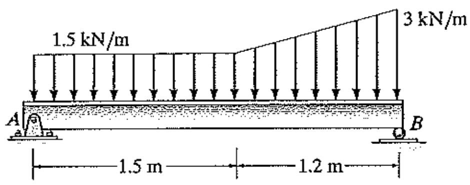
Prob. 2–19

***2-20.** Determine the support reactions on the beam.



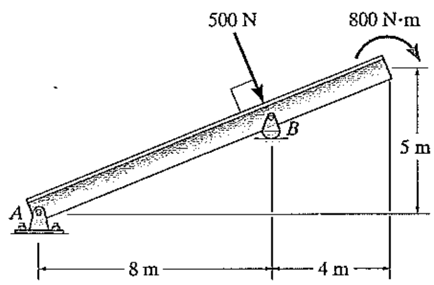
Prob. 2–20

2-21. Determine the reactions at the supports.



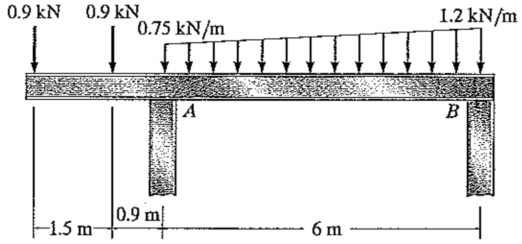
Prob. 2–21

2-22. Determine the reactions at the supports.



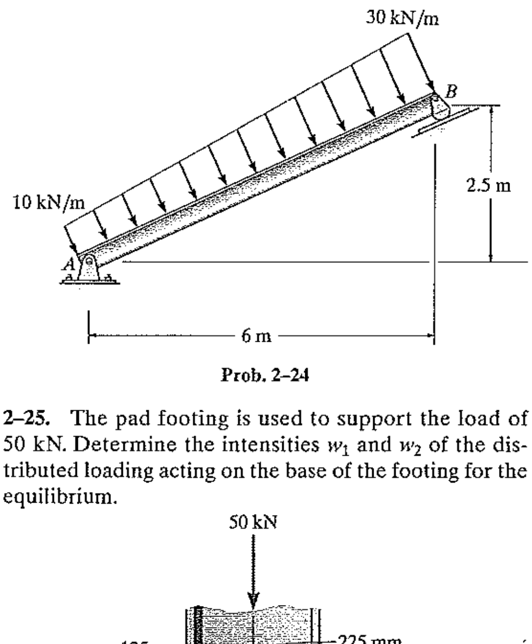
Prob. 2–22

2–23. Determine the vertical reactions at the supports A and B. Assume A is a roller and B is a pin.



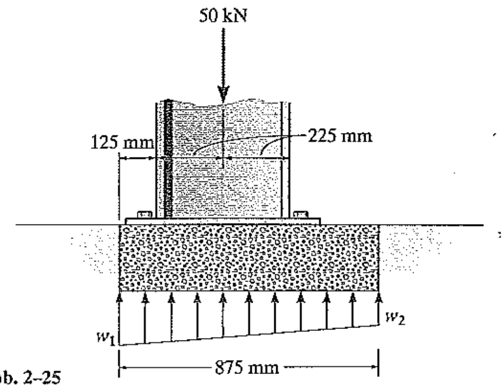
Prob. 2–23

***2–24.** Determine the reactions on the beam.



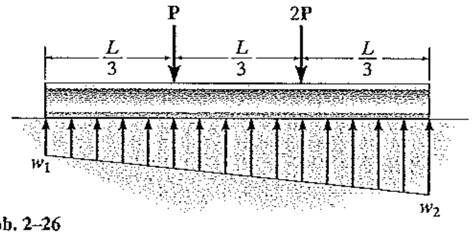
Prob. 2–24

2–25. The pad footing is used to support the load of 50 kN. Determine the intensities w_1 and w_2 of the distributed loading acting on the base of the footing for the equilibrium.



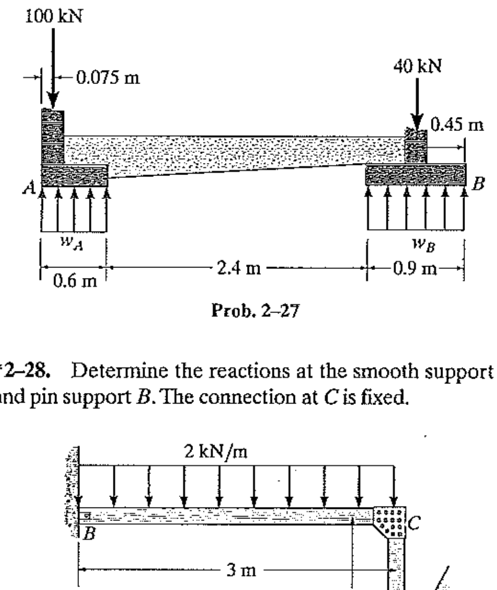
Prob. 2–25

2–26. The beam is subjected to the two concentrated loads as shown. Assuming that the foundation exerts a linearly varying load distribution on its bottom, determine the load intensities w_1 and w_2 for equilibrium (a) in terms of the parameters shown; (b) set $P = 2$ kN, $L = 3$ m.



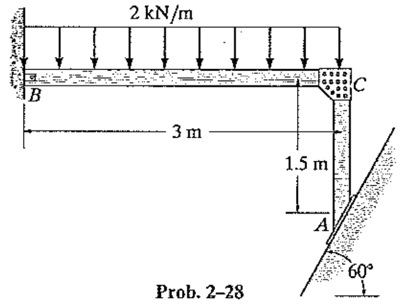
Prob. 2–26

2–27. The cantilever footing is used to support a wall near its edge A so that it causes a uniform soil pressure under the footing. Determine the uniform distribution loads, w_A and w_B, measured in kN/m at pads A and B, necessary to support the wall forces of 40 kN and 100 kN.



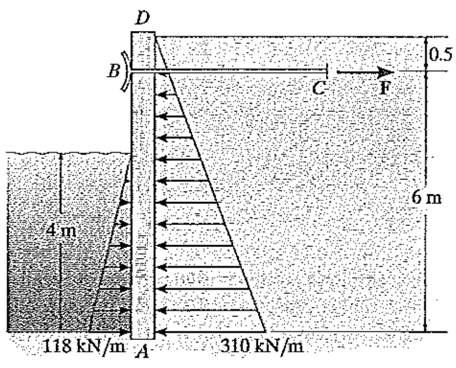
Prob. 2–27

***2–28.** Determine the reactions at the smooth support A and pin support B. The connection at C is fixed.



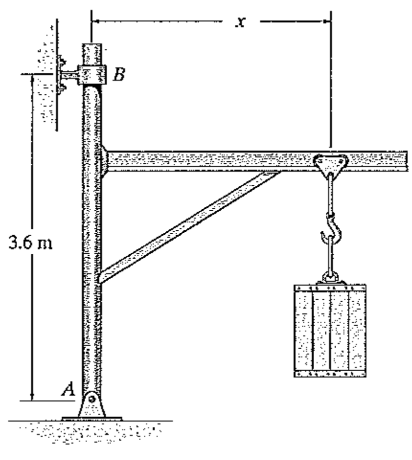
Prob. 2–28

2–29. The bulkhead AD is subjected to both water and soil-backfill pressures. Assuming AD is "pinned" to the ground at A, determine the horizontal and vertical reactions there and also the required tension in the ground anchor BC necessary for equilibrium. The bulkhead has a mass of 800 kg.



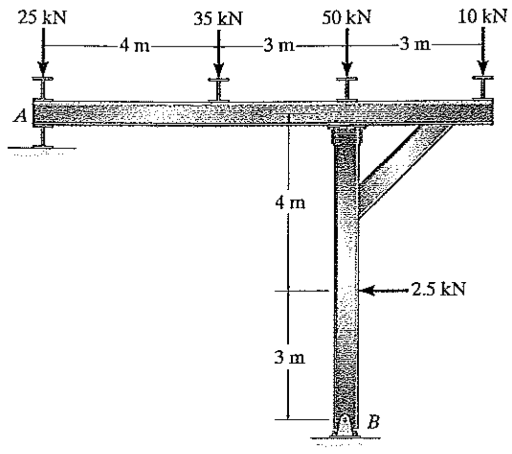
Prob. 2–29

2–30. The jib crane is pin-connected at A and supported by a smooth collar at B. Determine the roller placement x of the 22.5-kN load so that it gives the maximum and minimum reactions at the supports. Calculate these reactions in each case. Neglect the weight of the crane. Require $1.2\text{ m} \leq x \leq 3\text{ m}$.



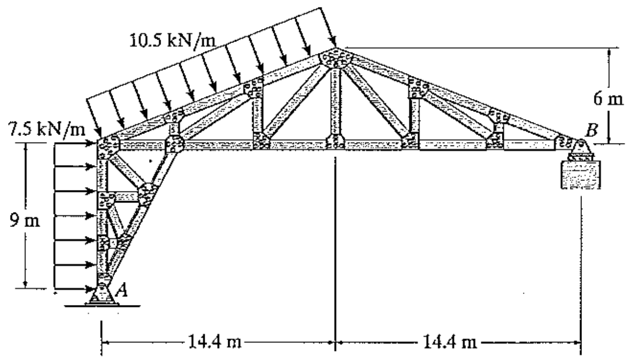
Prob. 2–30

2–31. Determine the reactions at the supports A and B of the frame. Assume that the support at A is a roller.



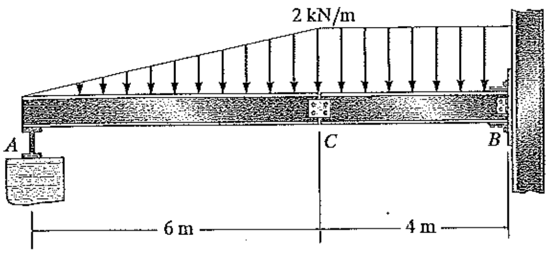
Prob. 2–31

***2–32.** Determine the reactions at the truss supports A and B. The distributed loading is caused by wind pressure.



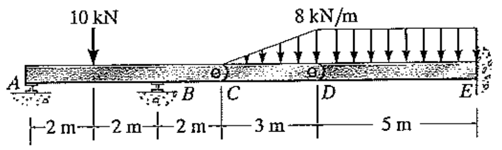
Prob. 2–32

2–33. Determine the reactions at the supports A and B of the compound beam. Assume A is a roller, C is a pin, and B is fixed.



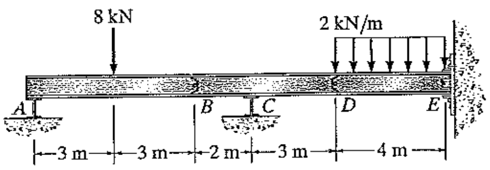
Prob. 2–33

2–34. Determine the reactions at A, B, and E. Assume A and B are roller supported.



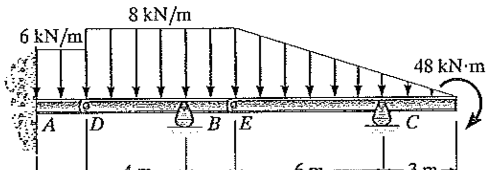
Prob. 2–34

2–35. Determine the reactions at the supports A, C, and E. Assume A and C are rollers, E is fixed, and B and D are pins.



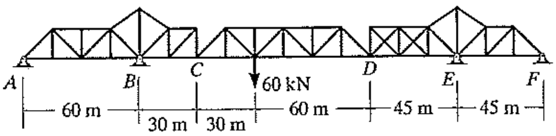
Prob. 2–35

***2–36.** The compound beam is fixed supported at A and supported by rockers at B and C. If there are hinges (pins) at D and E, determine the reactions at the supports A, B, and C.



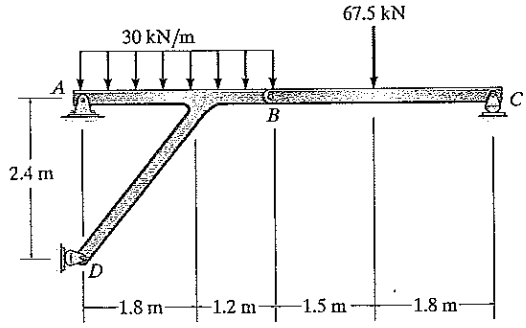
Prob. 2–36

2–37. The construction features of a cantilever truss bridge are shown in the figure. Here it can be seen that the center truss CD is suspended by the cantilever arms ABC and DEF. C and D are pins. Determine the vertical reactions at the supports A, B, E, and F if a 60-kN load is applied to the center truss.



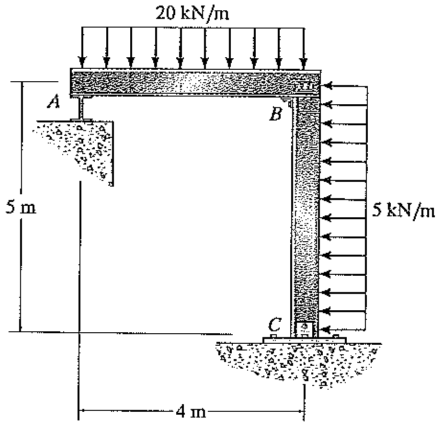
Prob. 2–37

2–38. Determine the reactions at the supports A, C, and D. B is pinned.



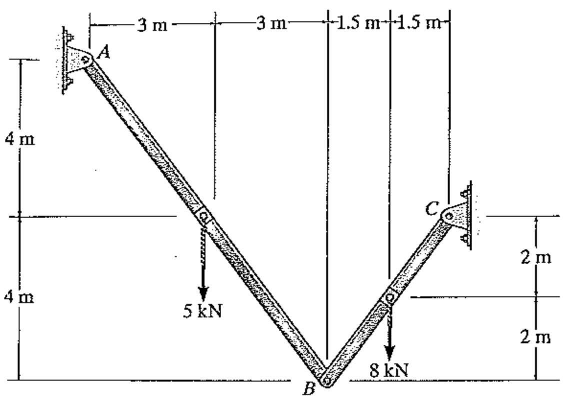
Prob. 2–38

2–39. Determine the reactions at the supports A and C. Assume the support at A is a roller, B is a fixed-connected joint, and C is a pin.



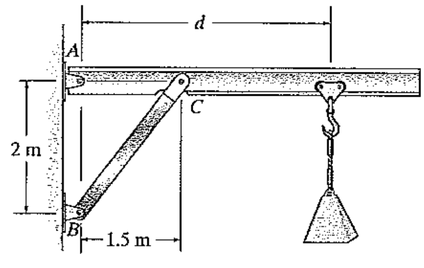
Prob. 2–39

2–41. Determine the horizontal and vertical components of reaction acting at the pins A and C.



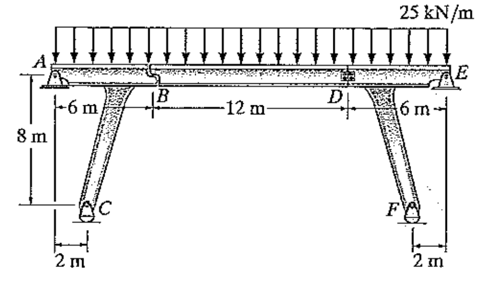
Prob. 2–41

***2–40.** The mass of 700 kg is suspended from a trolley which moves along the crane rail from $d = 1.7$ m to $d = 3.5$ m. Determine the force along the pin-connected knee strut BC (short link) and the magnitude of force at pin A as a function of position d. Plot these results of F_{BC} and F_A (ordinate) versus d (abscissa).



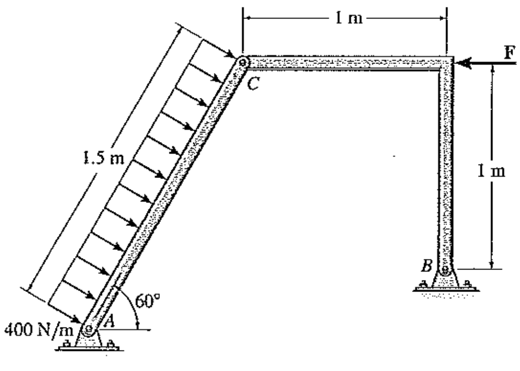
Prob. 2–40

2–42. The bridge frame consists of three segments which can be considered pinned at A, D, and E, rocker supported at C and F, and roller supported at B. Determine the horizontal and vertical components of reaction at all these supports due to the loading shown.



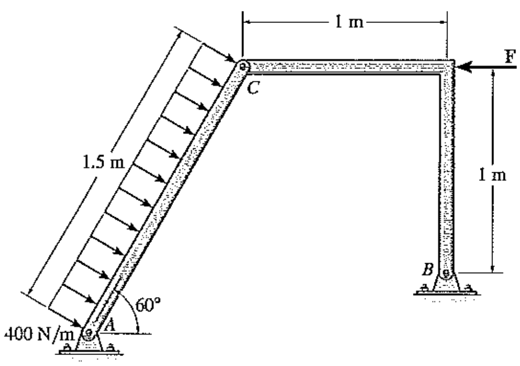
Prob. 2–42

2–43. Determine the horizontal and vertical components of force that the pins A and B exert on the two-member frame. Set $F = 0$.



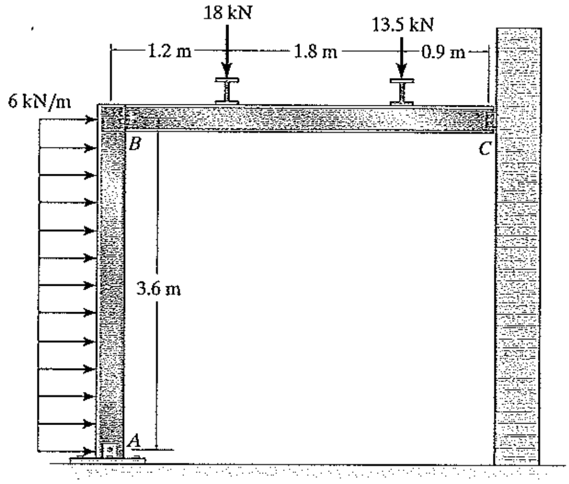
Prob. 2–43

***2–44.** Determine the horizontal and vertical components of force that pins A and B exert on the two-member frame. Set $F = 500$ N.



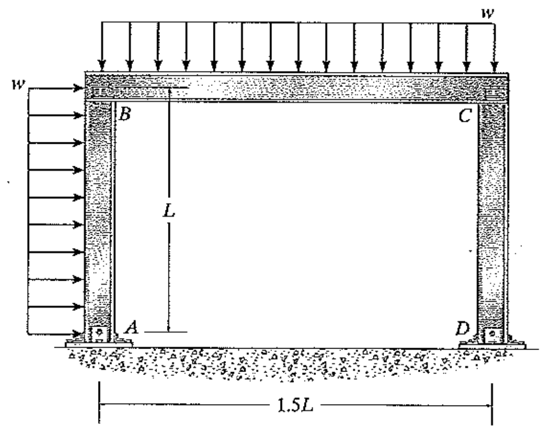
Prob. 2–44

2–45. Determine the horizontal and vertical components of force at the connections A, B, and C. Assume each of these connections is a pin.



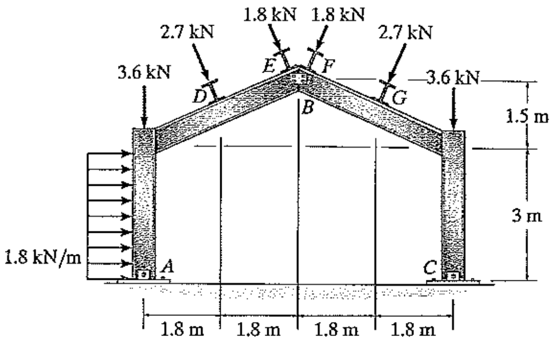
Prob. 2–45

2–46. Determine the reactions at the supports A and D. Assume A is fixed and B and C and D are pins.



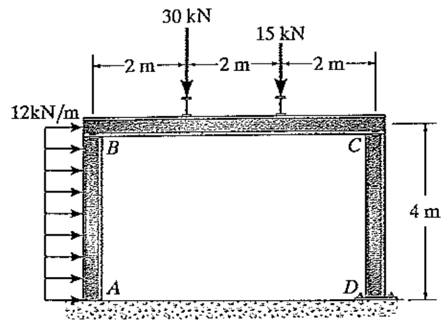
Prob. 2–46

2–47. Determine the horizontal and vertical reactions the connections A and C of the gable frame. Assume that A, B, and C are pin connections. The purlin loads such as D and E are applied perpendicular to the center line of each girder.



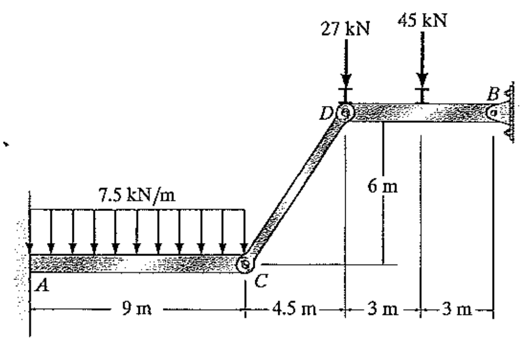
Prob. 2–47

2–49. Determine the reaction at the support A and D. Assume A is fixed and B, C, and D are pins.



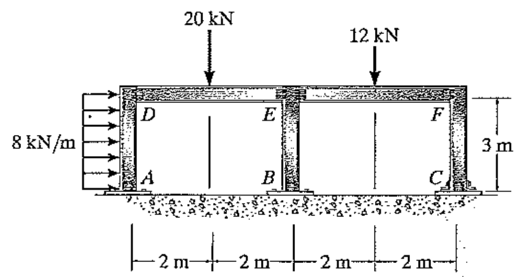
Prob. 2–49

***2–48.** Determine the reactions at the supports A and B.



Prob. 2–48

2–50. Determine the horizontal and vertical components of reaction at the supports A, B, and C. Assume the frame is pin-connected at A, B, D, E, and F, and there is a fixed connected joint at C.

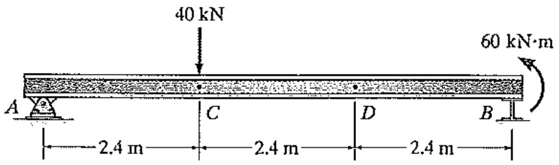


Prob. 2–50

PROBLEMS

4–1. Determine the internal shear, axial load, and bending moment in the beam at points C and D. Assume the support at B is a roller. Point C is located just to the right of the 40-kN load.

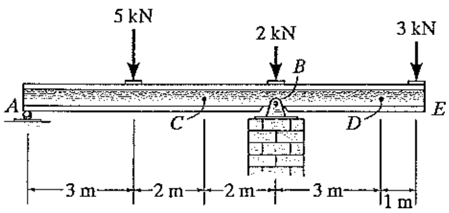
4–2. Draw the shear and moment diagrams for the beam in Prob. 4–1.



Probs. 4–1/4–2

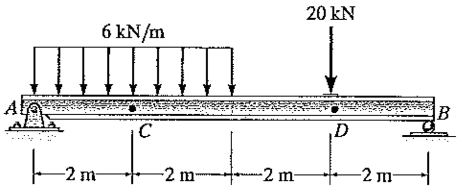
4–3. Determine the shear force and moment at points C and D.

***4–4.** Draw the shear and moment diagrams for the beam in Prob 4–3.



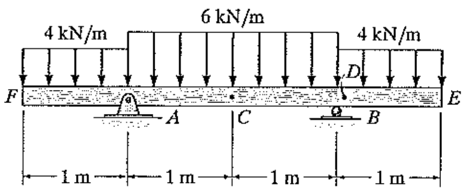
Probs. 4–3/4–4

4–5. Determine the internal normal force, shear force, and moment in the beam at points C and D. Point D is just to the right of the 20-kN load.



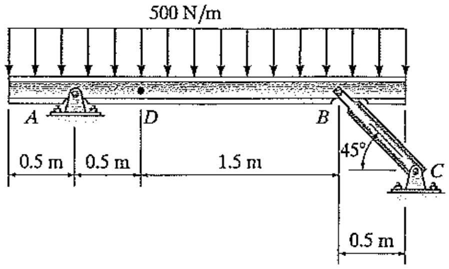
Prob. 4–5

4–6. Determine the internal normal force, shear force, and moment acting at point C and at point D, which is located just to the right of the roller support at B.



Prob. 4–6

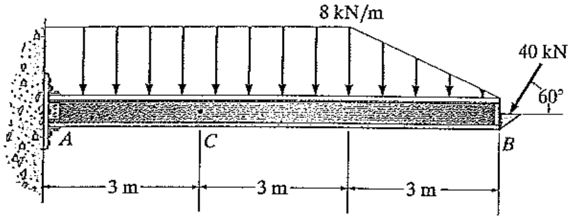
4–7. Determine the internal normal force, shear force, and moment at point D of the beam.



Prob. 4–7

*4–8. Determine the internal shear, axial load, and bending moment at point C.

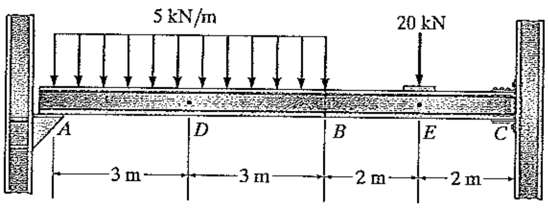
4–9. Draw the shear and moment diagrams for the beam in Prob. 4–8.



Probs. 4–8/4–9

4–10. Determine the internal shear, axial load, and bending moment in the beam at points D and E. Point E is just to the right of the 20-kN load. Assume A is a roller support, the splice at B is a pin, and C is a fixed support.

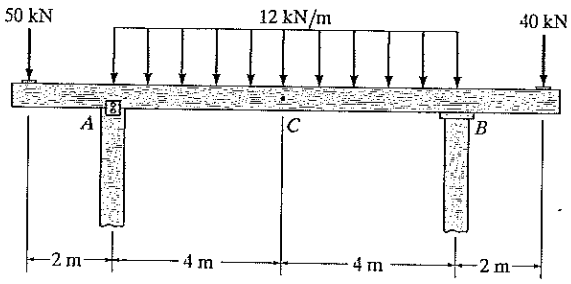
4–11. Draw the shear and moment diagrams for the beam in Prob. 4–10.



Probs. 4–10/4–11

*4–12. Determine the internal shear, axial load, and bending moment at point C. Assume the support at A is a pin and B is a roller.

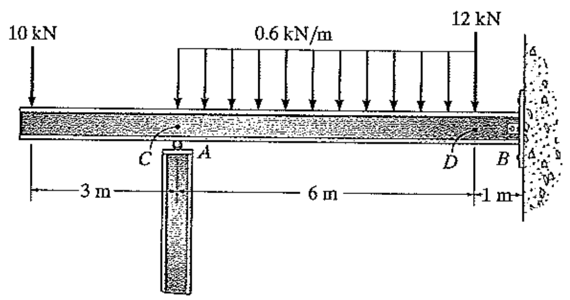
4–13. Draw the shear and moment diagrams of the beam in Prob. 4–12.



Probs. 4–12/4–13

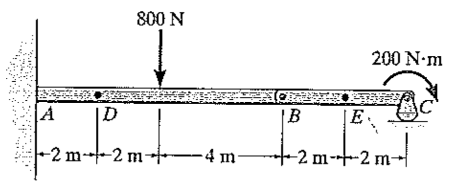
4–14. Determine the internal shear, axial load, and bending moment at (a) point C, which is just to the right of the roller at A, and (b) point D, which is just to the left of the 12-kN concentrated force. Assume the support at B is a pin.

4–15. Draw the shear and moment diagrams for the beam in Prob. 4–14.



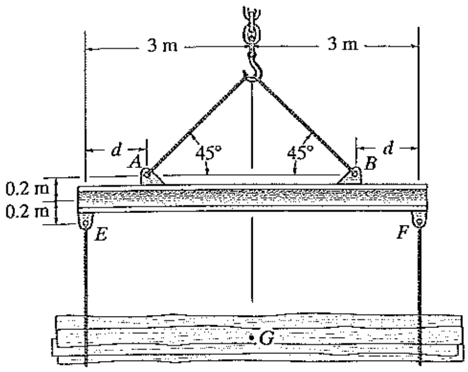
Probs. 4–14/4–15

*4–16. Determine the internal normal force, shear force, and moment at points E and D of the compound beam.



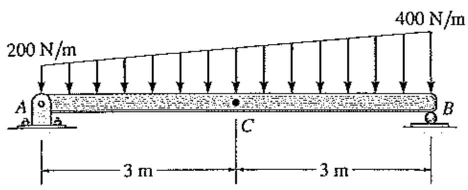
Prob. 4–16

4–17. The strongback or lifting beam is used for materials handling. If the suspended load has a weight of 2 kN and a center of gravity of G, determine the placement d of the padeyes on the top of the beam so that there is no moment developed within the length AB of the beam. The lifting bridle has two legs that are positioned at 45°, as shown.



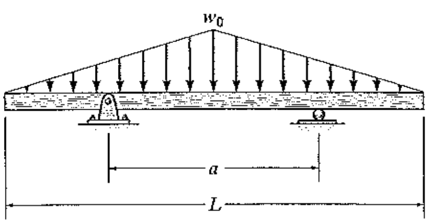
Prob. 4–17

4–18. Determine the internal normal force, shear force, and moment at point C of the beam.



Prob. 4–18

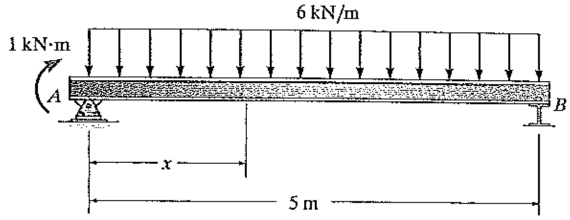
4–19. Determine the distance a between the supports in terms of the beam's length L so that the bending moment in the *symmetric* shaft is zero at the center. The intensity of the distributed load at the center is w_0.



Prob. 4–19

***4–20.** Determine the shear and moment in the beam as a function of x. Assume the support at B is a roller.

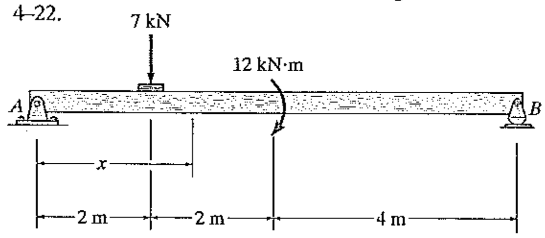
4–21. Draw the shear and moment diagrams for the beam in Prob. 4–20.



Probs. 4–20/4–21

4–22. Determine the shear and moment in the function of x, where $2\text{ m} < x < 4\text{ m}$.

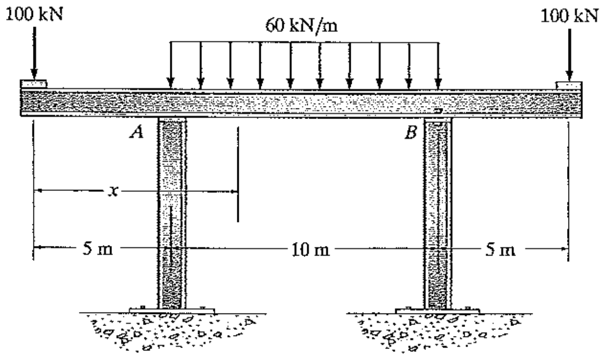
4–23. Draw the shear and moment diagrams for Prob. 4–22.



Probs. 4–22/4–23

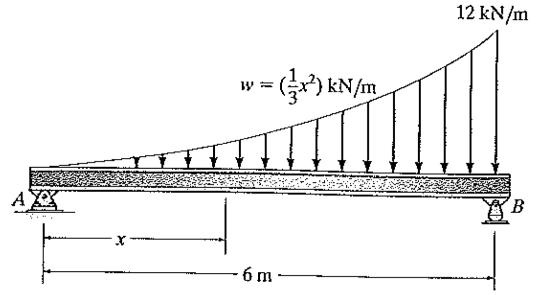
***4–24.** Determine the shear and moment in the beam as a function of x, where $5\text{ m} < x < 15\text{ m}$. Assume the supports at A is a roller and B is a pin.

4–25. Draw the shear and moment diagrams for the beam in Prob. 4–24.



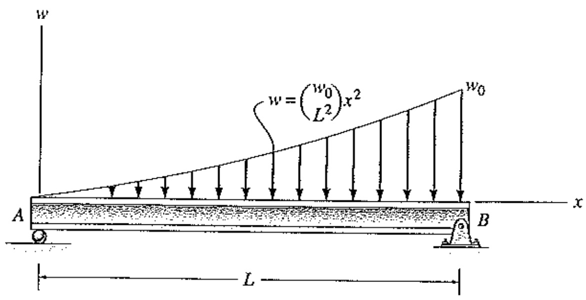
Probs. 4–24/4–25

4–26. Determine the shear and moment in the beam as a function of x.



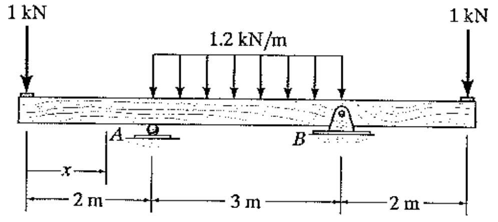
Prob. 4–26

4–27. Draw the shear and moment diagrams for the beam.



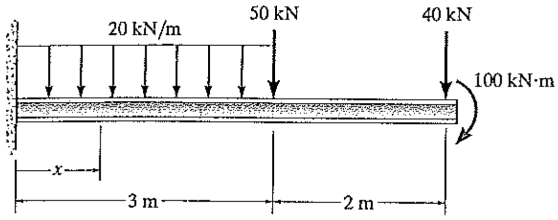
Prob. 4–27

***4–28.** Draw the shear and moment diagrams for the wood beam, and determine the shear and moment throughout the beam as functions of x.



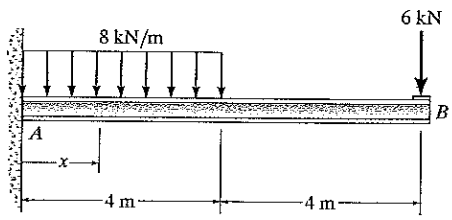
Prob. 4–28

4–29. Draw the shear and moment diagrams for the beam, and determine the shear and moment throughout the beam as functions of x.



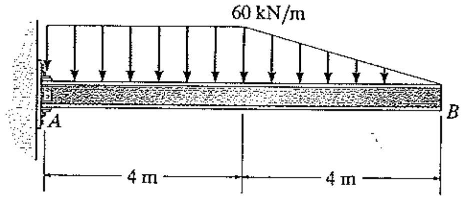
Prob. 4–29

4–30. Draw the shear and moment diagrams for the beam, and determine the shear and moment throughout the beam as functions of x.



Prob. 4–30

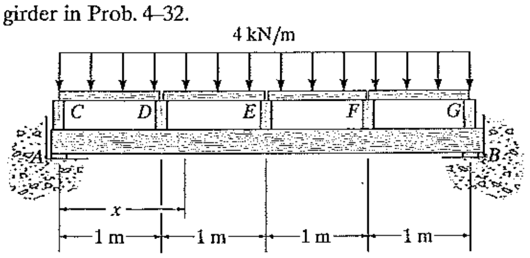
4–31. Draw the shear and moment diagrams for the tapered cantilever beam.



Prob. 4–31

*4–32. Determine the shear and moment in the floor girder as a function of x, where $1 \text{ m} < x < 2 \text{ m}$. Assume the support at A is a roller and B is a pin. The floor boards are simply supported on the joists at C, D, E, F, and G.

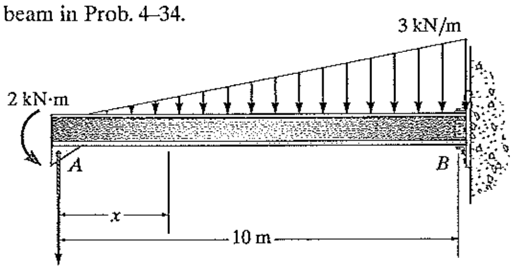
4–33. Draw the shear and moment diagrams for the floor girder in Prob. 4–32.



Probs. 4–32/4–33

4–34. Determine the shear and moment in the beam as a function of x.

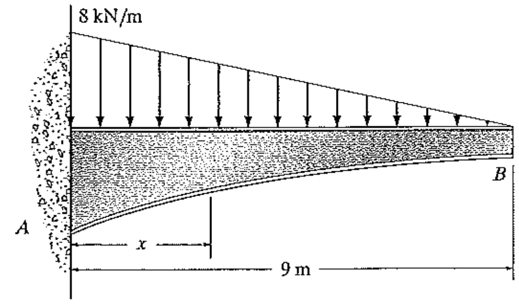
4–35. Draw the shear and moment diagrams for the beam in Prob. 4–34.



Probs. 4–34/4–35

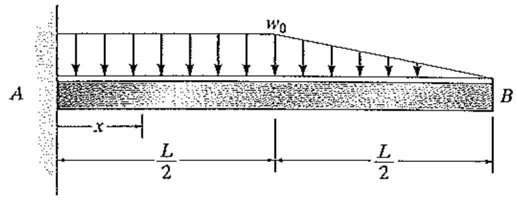
*4–36. Determine the shear and moment in the tapered beam as a function of x.

4–37. Draw the shear and moment diagrams for the beam in Prob. 4–36.



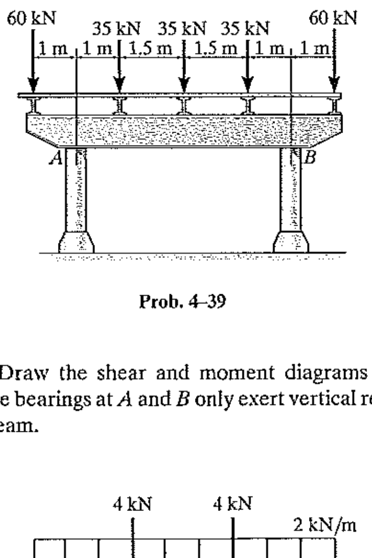
Probs. 4–36/4–37

4–38. Draw the shear and moment diagrams for the beam, and determine the shear and moment in the beam as functions of x.



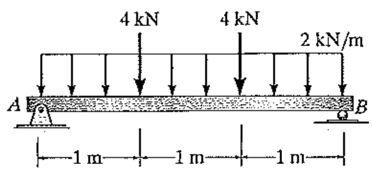
Prob. 4–38

4–39. A reinforced concrete pier is used to support the stringers for a bridge deck. Draw the shear and moment diagrams for the pier when it is subjected to the stringer loads shown. Assume the columns at A and B exert only vertical reactions on the pier.



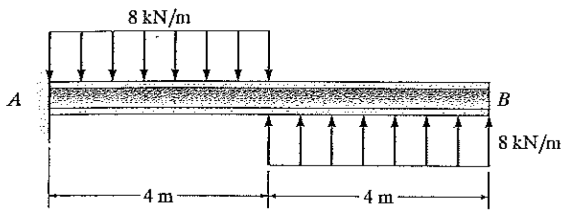
Prob. 4–39

*4–40. Draw the shear and moment diagrams for the beam. The bearings at A and B only exert vertical reactions on the beam.



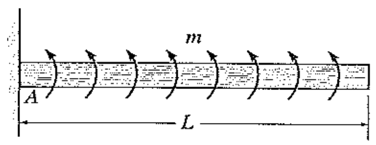
Prob. 4–40

4–41. Draw the shear and moment diagrams for the beam.



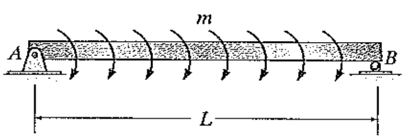
Prob. 4–41

4–42. The beam is subjected to the uniformly distributed moment m (moment/length). Draw the shear and moment diagrams for the beam.



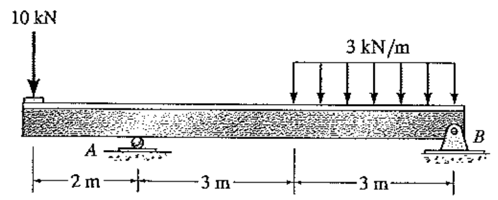
Prob. 4–42

4–43. The beam is subjected to the uniformly distributed moment m (moment/length). Draw the shear and moment diagrams for the beam.



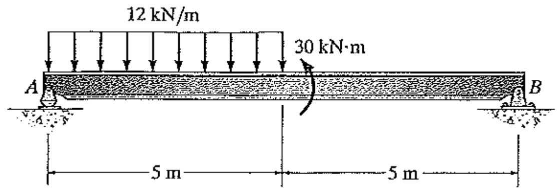
Prob. 4–43

***4–44.** The T-beam is subjected to the loading shown. Draw the shear and moment diagrams.



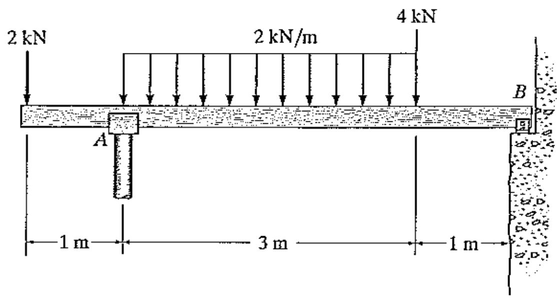
Prob. 4–44

4–45. Draw the shear and moment diagrams for the beam.



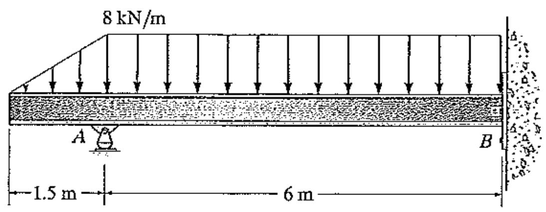
Prob. 4–45

4–46. Draw the shear and moment diagrams of the beam. Assume the support at A is a roller and B is a pin.



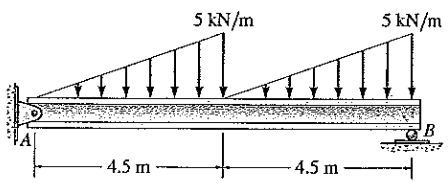
Prob. 4–46

4–47. Draw the shear and moment diagrams for the beam. Assume the support at B is a pin.



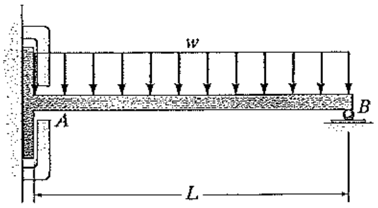
Prob. 4–47

***4–48.** Draw the shear and moment diagrams for the beam.



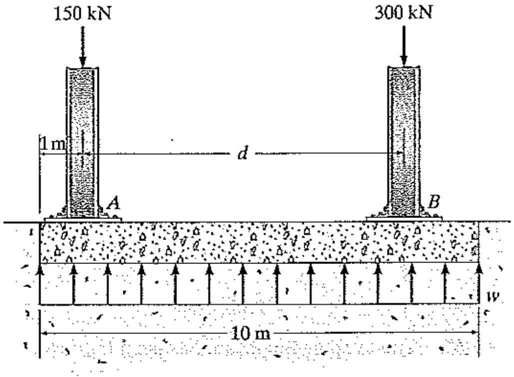
Prob. 4–48

4–49. Draw the shear and moment diagrams for the beam. It is supported by a smooth plate at A which slides within the groove and so it cannot support a vertical force, although it can support a moment and axial load.



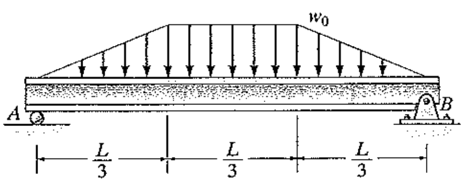
Prob. 4–49

4–50. The concrete girder supports the two column loads. If the soil pressure under the girder is assumed to be uniform, determine its intensity w and the placement d of the column at B. Draw the shear and moment diagrams for the girder.



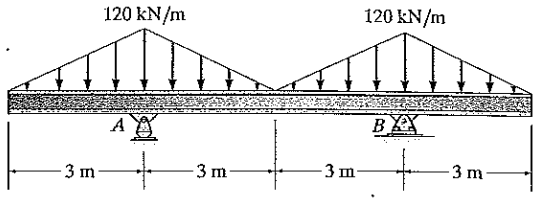
Prob. 4–50

4–51. Draw the shear and moment diagrams for the beam.



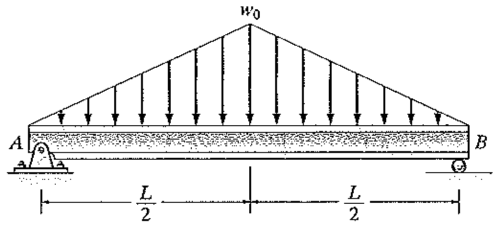
Prob. 4–51

***4–52.** Draw the shear and moment diagrams for the beam.



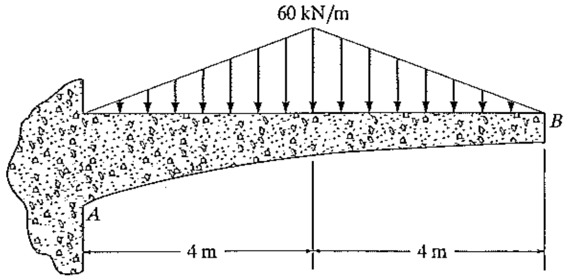
Prob. 4–52

4–53. Draw the shear and moment diagrams for the beam.



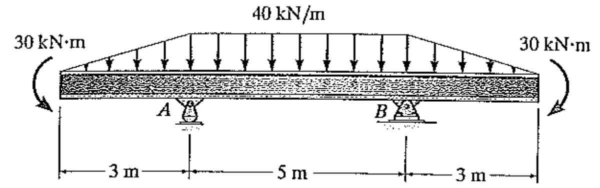
Prob. 4–53

4–54. Draw the shear and moment diagrams for the beam.



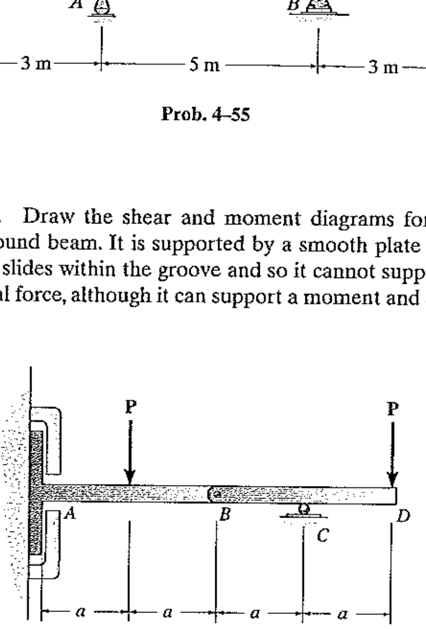
Prob. 4–54

4–55. Draw the shear and moment diagrams for the beam.



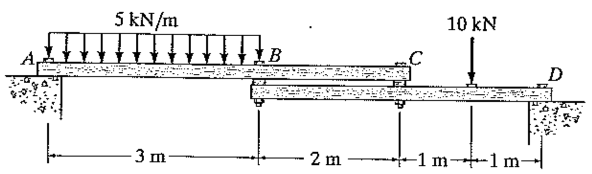
Prob. 4–55

***4–56.** Draw the shear and moment diagrams for the compound beam. It is supported by a smooth plate at A which slides within the groove and so it cannot support a vertical force, although it can support a moment and axial load.



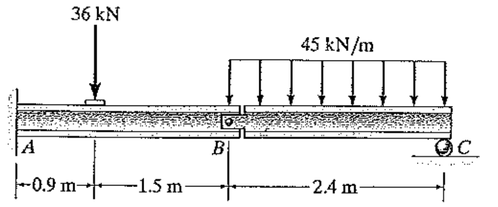
Prob. 4–56

4–57. The boards ABC and BCD are loosely bolted together as shown. If the bolts exert only vertical reactions on the boards, determine the reactions at the supports and draw the shear and moment diagrams for each board.



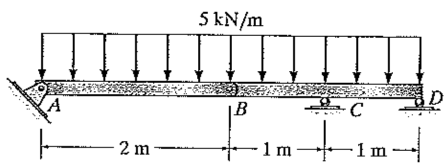
Prob. 4–57

4–58. Draw the shear and moment diagrams for the beam. The two segments are joined together at B.



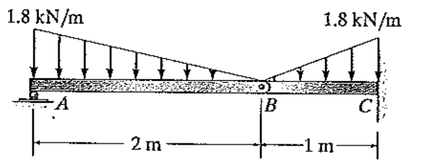
Prob. 4–58

4–59. Draw the shear and moment diagrams for the compound beam.



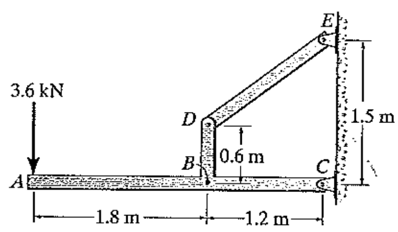
Prob. 4–59

***4–60.** Draw the shear and moment diagrams for the compound beam.



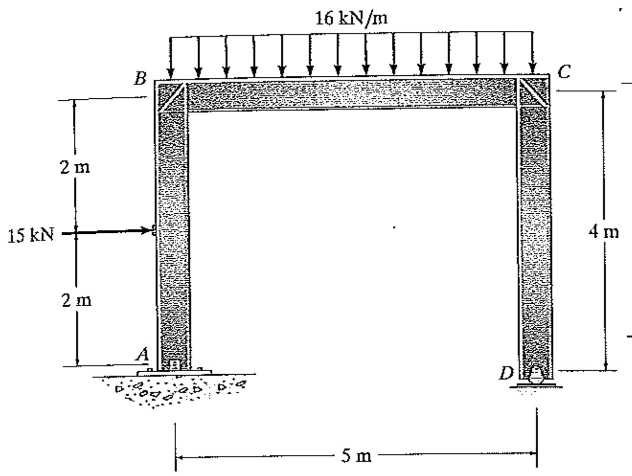
Prob. 4–60

4–61. The overhanging beam has been fabricated with a projected arm BD on it. Draw the shear and moment diagrams for the beam ABC if it supports a load of 800 lb. *Hint:* The loading in the supporting strut DE must be replaced by equivalent loads at point B on the axis of the beam.



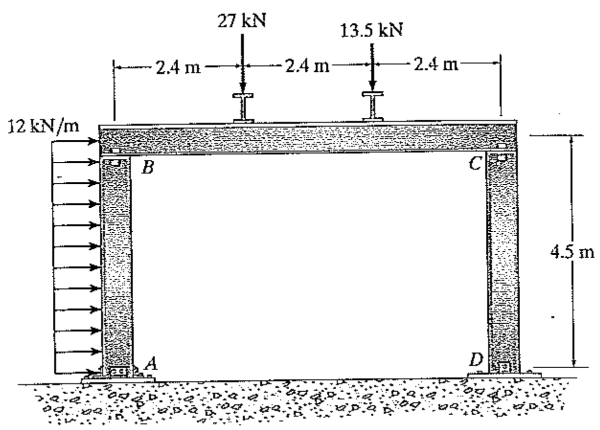
Prob. 4–61

4–62. Draw the shear and moment diagrams for each of the three members of the frame. Assume the support at A is a pin.



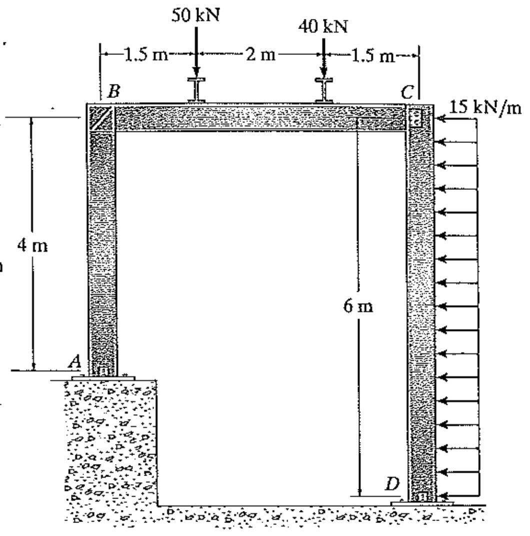
Prob. 4–62

4–63. Draw the shear and moment diagrams for each of the three members of the frame. Assume the frame is pin connected at B, C, and D and A is fixed.



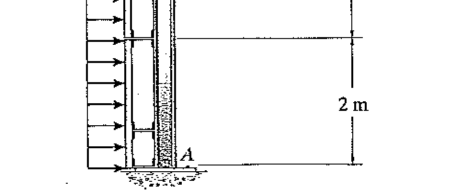
Prob. 4–63

***4–64.** Draw the shear and moment diagrams for each of the three members of the frame. Assume the frame is pin connected at A, C, and D and there is a fixed joint at B.



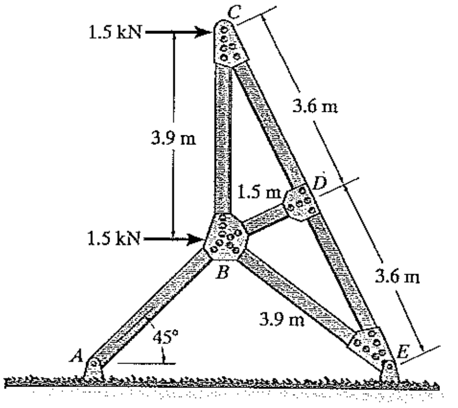
Prob. 4–64

4–65. Draw the shear and moment diagrams for each member of the frame. Assume the joint at A is a pin and support C is a roller. The joint at B is fixed. The wind load is transferred to the members at the girts and purlins from the simply supported wall and roof segments.



Prob. 4–65

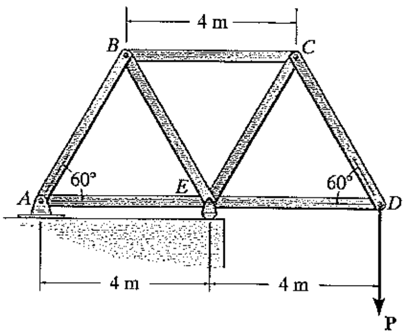
*3–4. A sign is subjected to a wind loading that exerts horizontal forces of 1.5 kN on joints B and C of one of the side supporting trusses. Determine the force in each member of the truss and state if the members are in tension or compression.



Prob. 3–4

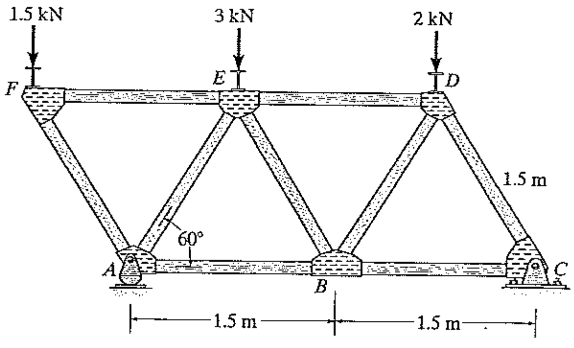
3–5. Determine the force in each member of the truss. State whether the members are in tension or compression. Set $P = 8$ kN.

3–6. If the maximum force that any member can support is 8 kN in tension and 6 kN in compression, determine the maximum force P that can be supported at joint D.



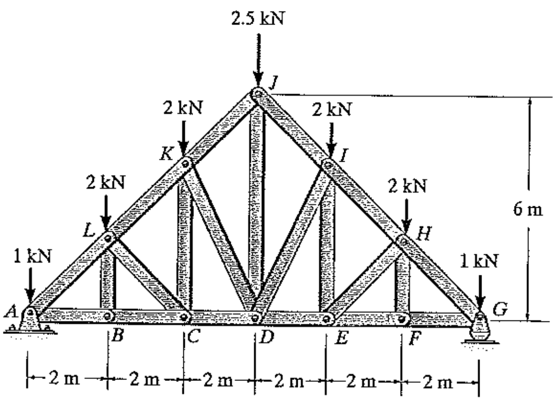
Probs. 3–5/3–6

3–7. Determine the force in each member of the truss. All interior angles are 60°. State if the members are in tension or compression. Assume all members are pin connected.



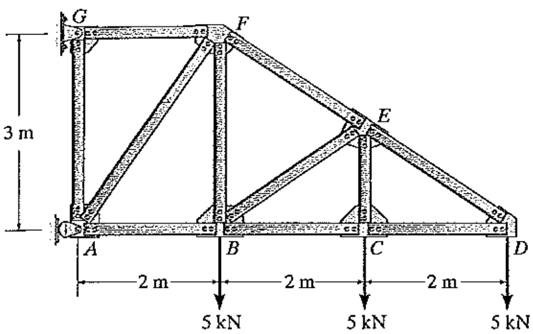
Prob. 3–7

*3–8. Determine the force in each member of the roof truss. State if the members are in tension or compression.



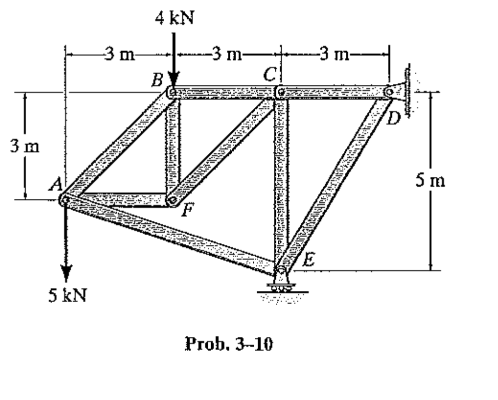
Prob. 3–8

3–9. Determine the force in each member of the truss. State if the members are in tension or compression. Assume all members are pin connected.



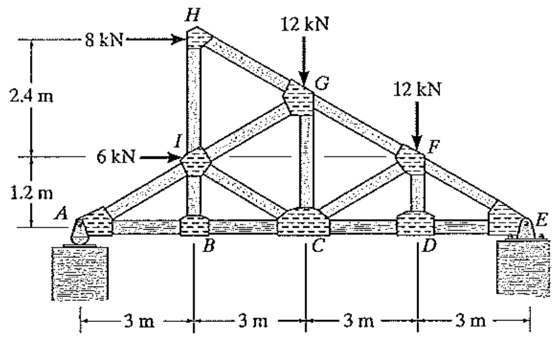
Prob. 3–9

3–10. Determine the force in each member of the truss and state if the members are in tension or compression.



Prob. 3–10

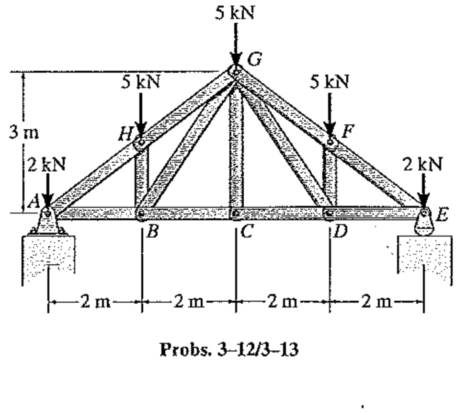
3–11. Determine the force in each member of the truss. Indicate if the members are in tension or compression. Assume all members are pin connected.



Prob. 3–11

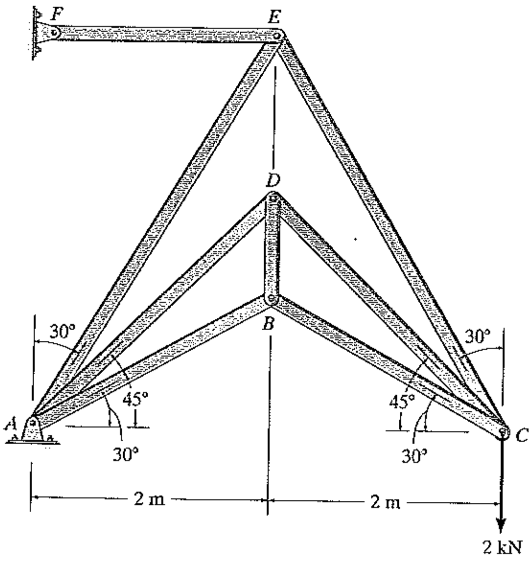
***3–12.** The *Howe truss* is subjected to the loading shown. Determine the force in members *GF*, *CD*, and *GC*, and state if the members are in tension or compression.

3–13. The *Howe truss* is subjected to the loading shown. Determine the force in members *GH*, *BC*, and *BG* of the truss and state if the members are in tension or compression.



Probs. 3–12/3–13

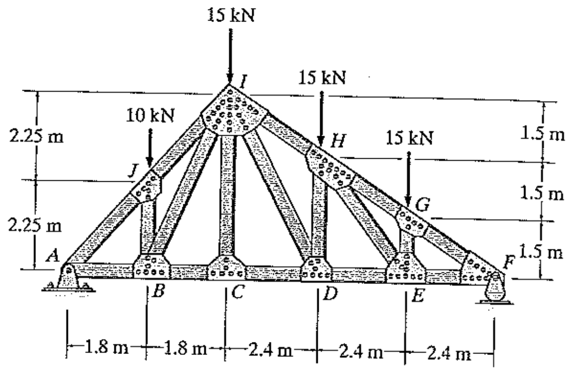
3–14. Determine the force in each member of the truss. State if the members are in tension or compression.



Prob. 3–14

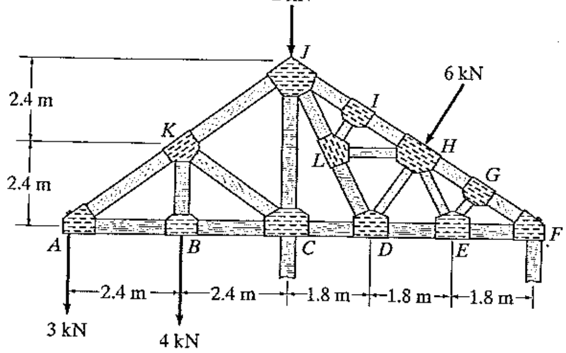
*3–16. Determine the force in each member of the roof truss. State if the members are in tension or compression.

3–17. Solve Prob. 3–16 assuming there is *no* external load on joints *J*, *H*, and *G* and only the vertical load of 15 kN exists on joint *I*.



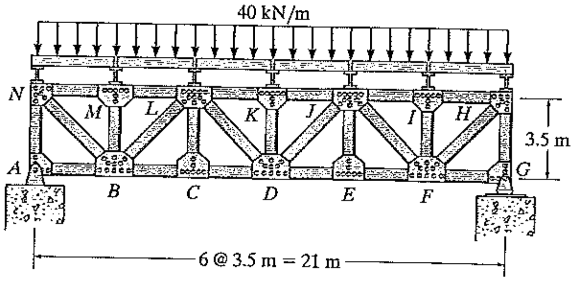
Probs. 3–16/3–17

3–15. Determine the force in members *KJ*, *JC*, and *CD*. State if the members are in tension or compression. Assume the truss is pin connected at *F* and roller supported at *C* and the members are pin connected.



Prob. 3–15

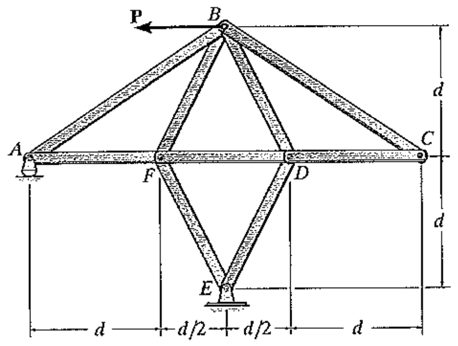
3–18. The truss shown is used to support the floor deck. The uniform load on the deck is 40 kN/m. This load is transferred from the deck to the floor beams, which rest on the top joints of the truss. Determine the force in each member of the truss, and state if the members are in tension or compression. Assume all members are pin connected.



Prob. 3–18

3–19. Determine the force in each member of the truss in terms of the load P, and indicate whether the members are in tension or compression.

*3–20. If the maximum force that any member can support is 4 kN in tension and 3 kN in compression, determine the maximum force P that can be supported at point B. Take $d = 1$ m.

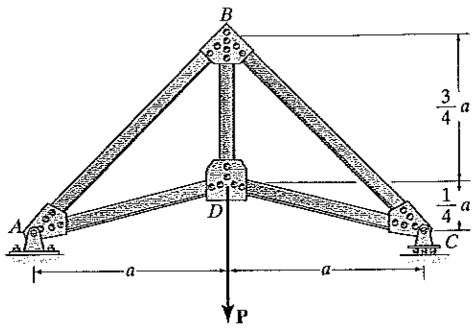


Probs. 3–19/3–20

3–21. Determine the force in each member of the truss in terms of the load P and state if the members are in tension or compression.

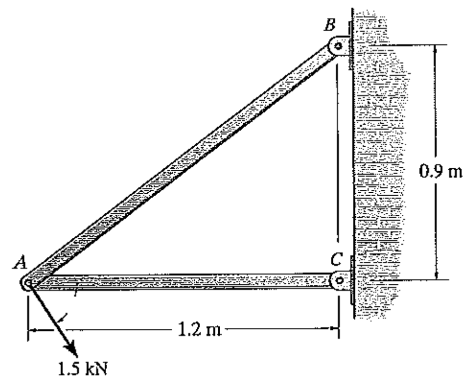
3–22. Members AB and BC can each support a maximum compressive force of 4 kN, and members AD, DC, and BD can support a maximum tensile force of 7.5 kN. If $a = 3$ m, determine the greatest load P the truss can support.

3–23. Members AB and BC can each support a maximum compressive force of 4 kN, and members AD, DC, and BD can support a maximum tensile force of 10 kN. If $a = 1.8$ m, determine the greatest load P the truss can support.



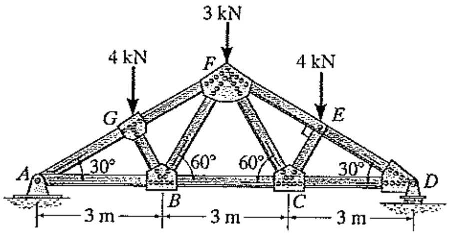
Probs. 3–21/3–22/3–23

*3–24. The two-member truss is subjected to the force of 1.5 kN. Determine the range of θ for application of the load so that the force in either member does not exceed 2 kN (T) or 1 kN (C).



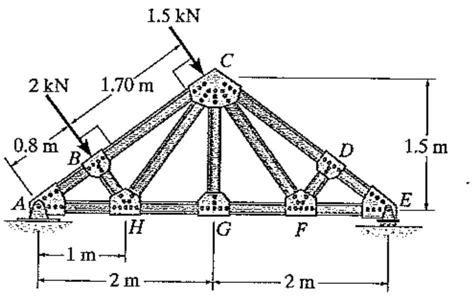
Prob. 3–24

3–25. Determine the force in members *GF*, *FB*, and *BC* of the *Fink truss* and state if the members are in tension or compression.



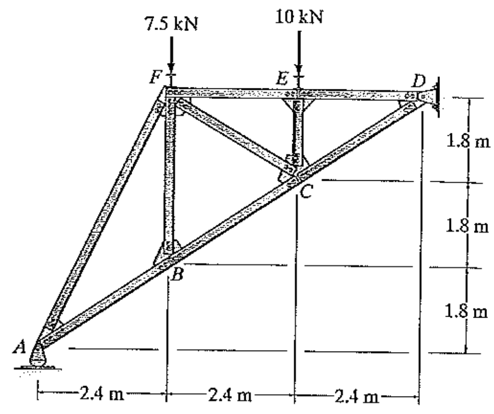
Prob. 3–25

3–26. Determine the force in members *GF*, *CF*, and *CD* of the roof truss and indicate if the members are in tension or compression.



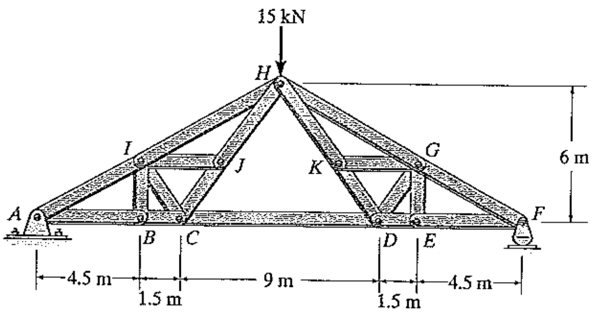
Prob. 3–26

3–27. Determine the force in members *FC*, *BC*, and *FE*. State if the members are in tension or compression. Assume all members are pin connected.



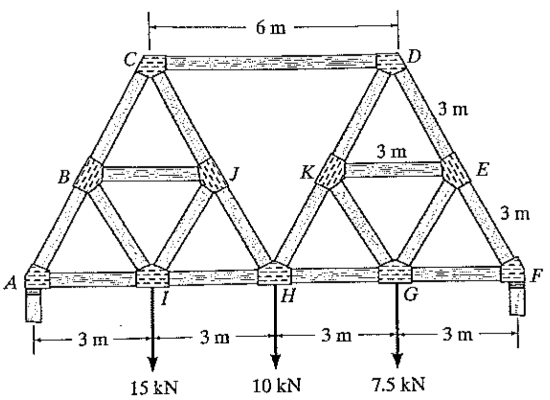
Prob. 3–27

***3–28.** Specify the type of compound truss and determine the force in members *JH*, *IH*, and *CD*. State if the members are in tension or compression. Assume all members are pin connected.



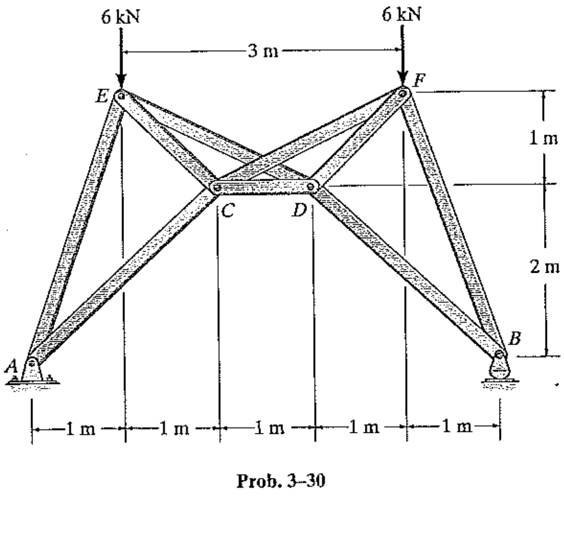
Prob. 3–28

3–29. Specify the type of compound truss and determine the force in members JH, BJ, and BI. State if the members are in tension or compression. The internal angle between any two members is 60°. The truss is pin supported at A and roller supported at F. Assume all members are pin connected.



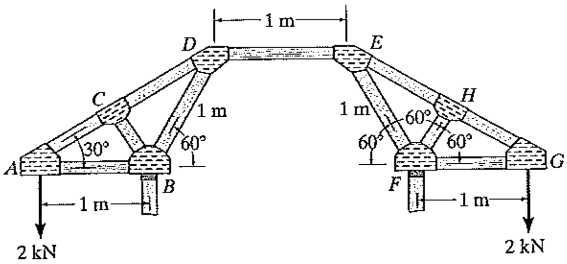
Prob. 3–29

3–30. Specify the type of compound truss. Trusses ACE and BDF are connected by three bars CF, ED, and CD. Determine the force in each member and state if the members are in tension or compression.



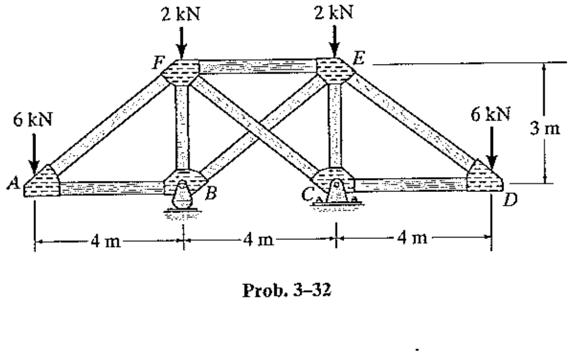
Prob. 3–30

3–31. Determine the force in each member. State if the members are in tension or compression. Assume the supports are at B and F and the members are pin connected.



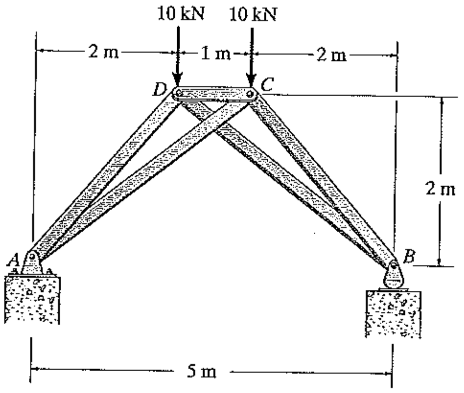
Prob. 3–31

***3–32.** Specify the type of compound truss and determine the force in each member. State if the members are in tension or compression. Assume the members are pin connected.



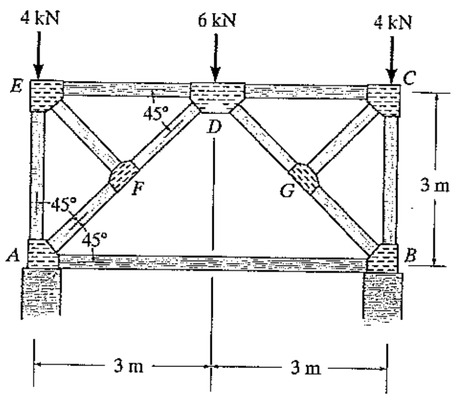
Prob. 3–32

3–33. Determine the force in each member. State if the members are in tension or compression.



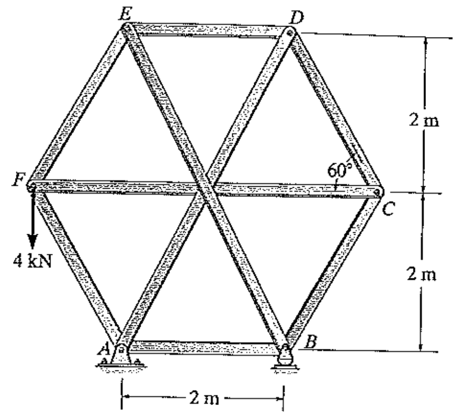
Prob. 3–33

3–34. Specify the type of compound truss and determine the force in each member. State if the members are in tension or compression. Assume the members are pin connected.



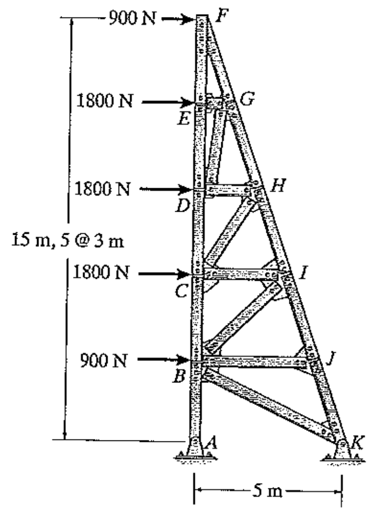
Prob. 3–34

3–35. Show by analysis that the complex truss is unstable. *Hint:* Substitute member EB with one placed between D and B.



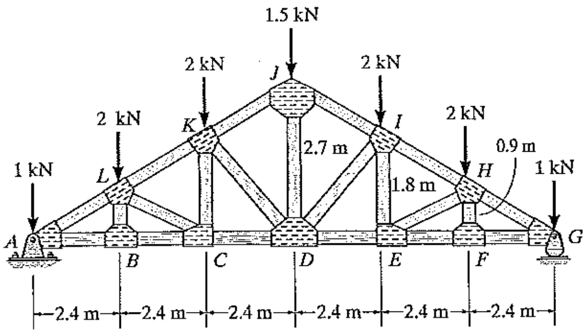
Prob. 3–35

*3–36. Determine the force in members CB, BI, and IJ of the truss used to support an outdoor sign. The design wind pressure acting on the face of the sign creates the loading shown on the joints. Indicate whether the members are in tension or compression. Assume all members are pin connected.



Prob. 3–36

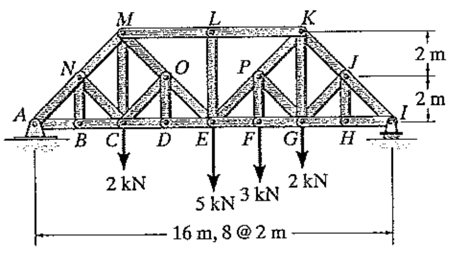
3–37. Determine the force in members *JI*, *DI*, and *DE* of the *Pratt* truss. State if the members are in tension or compression. Assume all members are pin connected.



Prob. 3–37

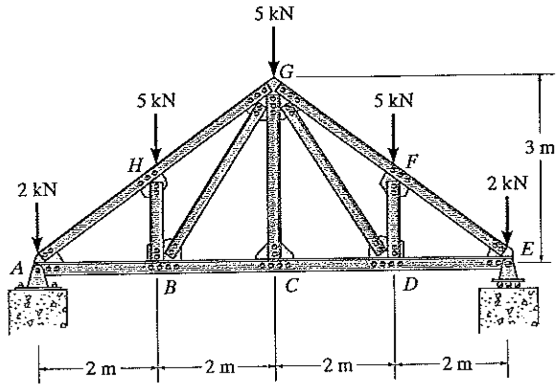
3–38. Determine the force in members *CD* and *CM* of the *Baltimore bridge truss* and state if the members are in tension or compression. Also, indicate all zero-force members.

3–39. Determine the force in members *EF*, *EP*, and *LK* of the *Baltimore bridge truss* and state if the members are in tension or compression. Also, indicate all zero-force members.



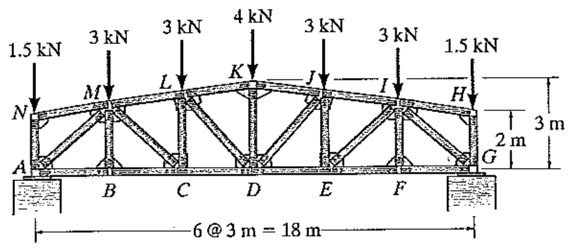
Probs. 3–38/3–39

***3–40.** The *Howe* truss is subjected to the loading shown. Determine the forces in members *GF*, *CD*, and *GC*. State if the members are in tension or compression. Assume all members are pin connected.



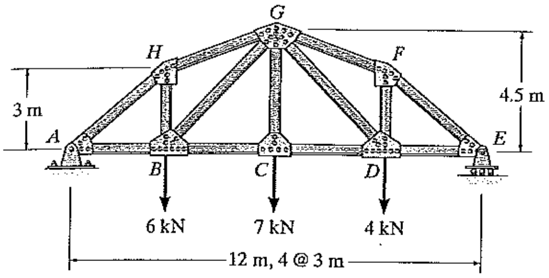
Prob. 3–40

3–41. The Warren truss is used to support the roof of an industrial building. The truss is simply supported on masonry walls at *A* and *G* so that only vertical reactions occur at these supports. Determine the force in members *LD*, *CD*, and *KD*. State if the members are in tension or compression. Assume all members are pin connected.



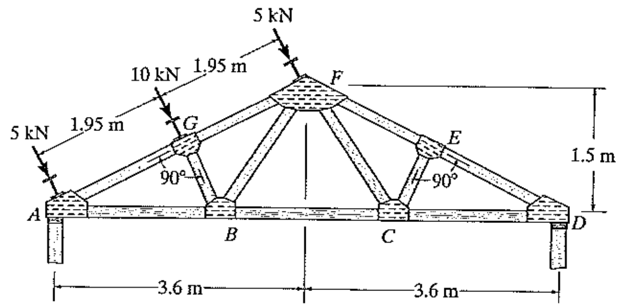
Prob. 3–41

3–42. Determine the force in members BG, HG, and BC of the truss and state if the members are in tension or compression.



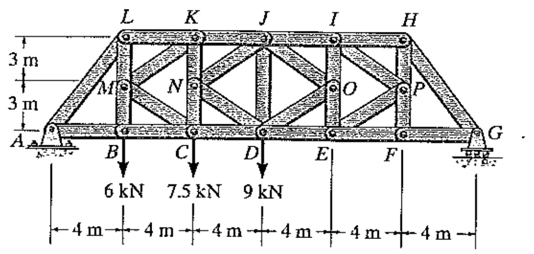
Prob. 3–42

3–43. Determine the force in members GF, GB, and BC of the truss. State if the members are in tension or compression. Assume the truss is pin connected at A and roller supported at D and the members are pin connected.



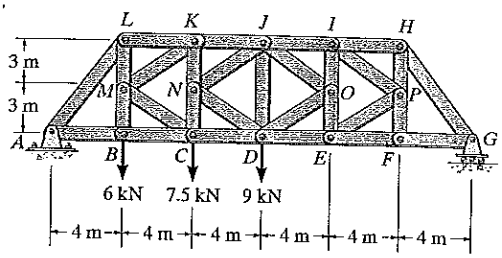
Prob. 3–43

*3–44. Determine the force in members KJ, NJ, ND, and CD of the K *truss*. Indicate if the members are in tension or compression.



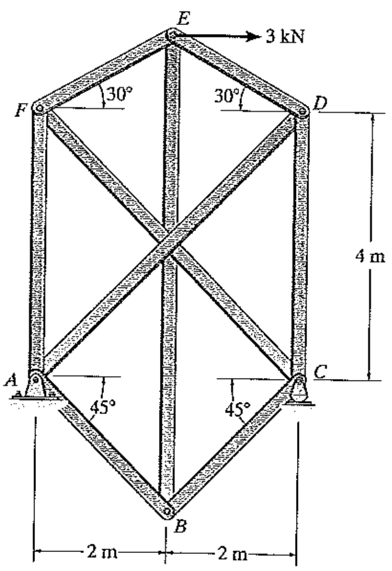
Prob. 3–44

3–45. Determine the force in members JI and DE of the K *truss*. Indicate if the members are in tension or compression.



Prob. 3–45

3–46. Determine the forces in all the members of the complex truss. State if the members are in tension or compression. *Hint:* Substitute member AD with one placed between E and C.

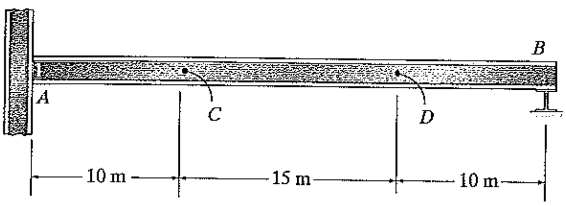


Prob. 3–46

PROBLEMS

6–1. Draw the influence lines for (a) the vertical reaction at A, (b) the shear at C, and (c) the moment at D. Assume the support at B is a roller and A is a pin. Solve this problem using the basic method of Sec. 6–1.

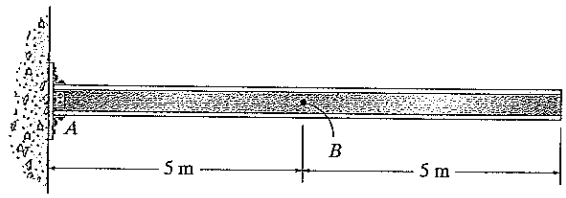
6–2. Solve Prob. 6–1 using Müller-Breslau's principle.



Probs. 6–1/6–2

6–5. Draw the influence lines for (a) the shear at the fixed support A, and (b) the moment at B.

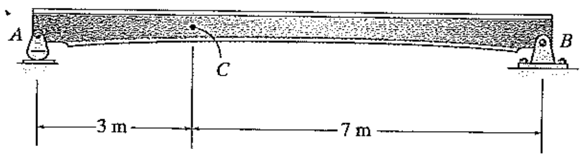
6–6. Solve Prob. 6–5 using Müller-Breslau's principle.



Probs. 6–5/6–6

6–3. Draw the influence lines for (a) the vertical reaction at B, (b) the shear at C, and (c) the moment at C. Solve this problem using the basic method of Sec. 6–1.

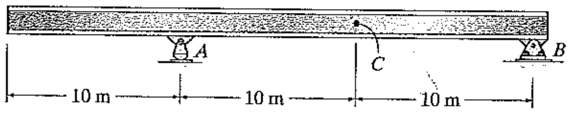
***6–4.** Solve Prob. 6–3 using Müller-Breslau's principle.



Probs. 6–3/6–4

6–7. Draw the influence line for (a) the vertical reaction at A, (b) the shear at C, and (c) the moment at C. Solve this problem using the basic method of Sec. 6–1.

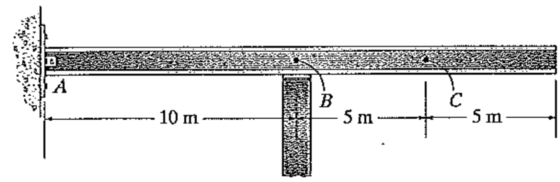
***6–8.** Solve Prob. 6–7 using Müller-Breslau's principle.



Probs. 6–7/6–8

6–9. Draw the influence line for the moment at C. Assume the support at A is a pin and B is a roller.

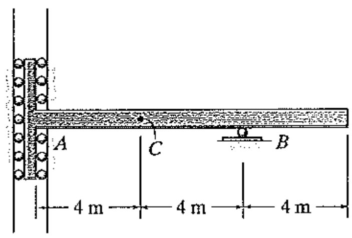
6–10. Solve Prob. 6–9 using Müller-Breslau's principle.



Probs. 6–9/6–10

6–11. Draw the influence line for (a) the moment at A. (b) the shear at C, and (c) the vertical reaction at B. Solve this problem using the basic method of Sec. 6–1.

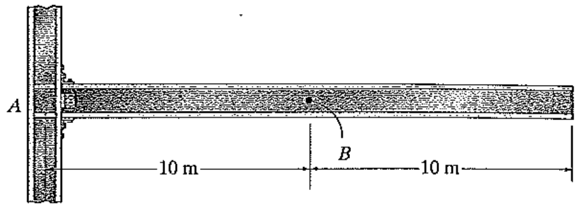
***6–12.** Solve Prob. 6–11. Using Müller-Breslau's principle.



Probs. 6–11/6–12

6–13. Draw the influence line for (a) the vertical reaction at A, (b) the moment at A, and (c) the shear at B. Assume the support at A is fixed. Solve this problem using the basic method of Sec. 6–1.

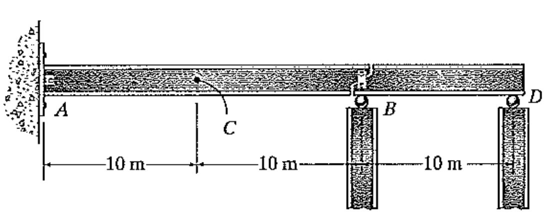
6–14. Solve Prob. 6–13 using Müller-Breslau's principle.



Probs. 6–13/6–14

6–15. Draw the influence lines for (a) the shear at C, (b) the moment at C, and (c) the vertical reaction at D. Indicate numerical values for the peaks. There is a short vertical link at B, and A is a pin support. Solve this problem using the basic method of Sec. 6–1.

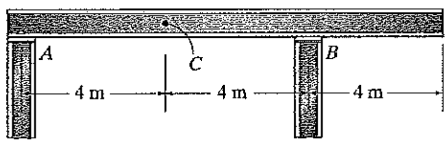
***6–16.** Solve Prob. 6–15 using Müller-Breslau's principle.



Probs. 6–15/6–16

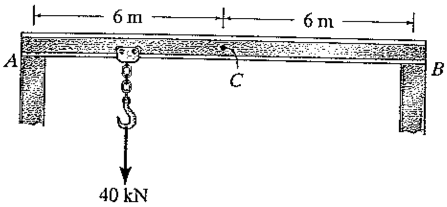
6–17. Draw the influence lines for the shear at C. Assume A is a roller support and B is a pin. Solve this problem using the basic method of Sec. 6–1.

6–18. Solve Prob. 6–17 using Müller-Breslau's principle.



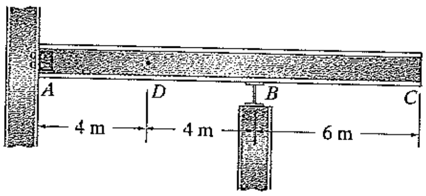
Probs. 6–17/6–18

6–19. The beam is subjected to a uniform dead load of 1.2 kN/m and a single live load of 40 kN. Determine (a) the maximum moment created by these loads at C, and (b) the maximum positive shear at C. Assume A is a pin, and B is a roller.



Prob. 6–19

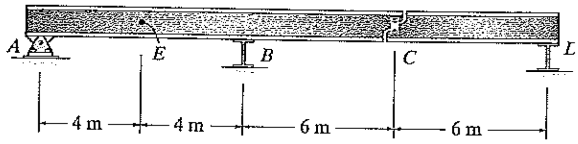
***6–20.** The beam supports a uniform live load of 1 kN/m and a live concentrated force of 2.5 kN. Determine (a) the maximum positive live moment that can be developed at D, and (b) the maximum positive live vertical reaction at B. Assume A is a pin support and B is a roller.



Prob. 6–20

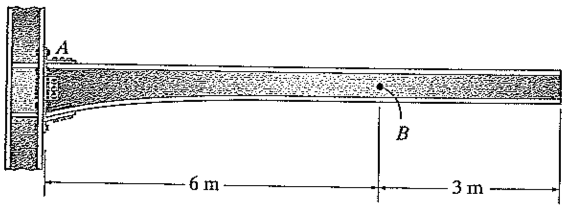
6–21. Draw the influence lines for (a) the vertical reaction at B, and (b) the moment at E. Assume the supports at B and D are rollers. There is a short link at C. Solve this problem using the basic method of Sec. 6–1.

6–22. Solve Prob. 6–21 using Müller-Breslau's principle.



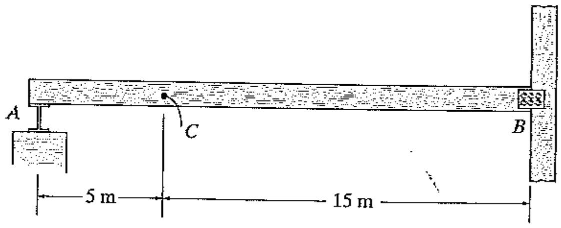
Probs. 6–21/6–22

6–23. A uniform live load of 3 kN/m and a single live concentrated force of 45 kN can be placed on the haunched girder. Determine (a) the maximum live negative moment at A, (b) the maximum live positive shear at B, and (c) the maximum live negative moment at B.



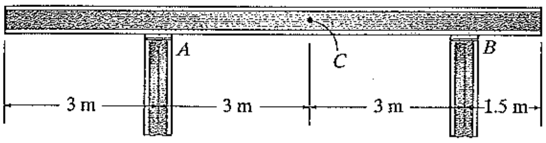
Prob. 6–23

***6–24.** The beam supports a uniform dead load of 500 N/m and a single live concentrated force of 3000 N. Determine (a) the maximum live moment that can be developed at C, and (b) the maximum live positive shear that can be developed at C. Assume the support at A is a roller and B is a pin.



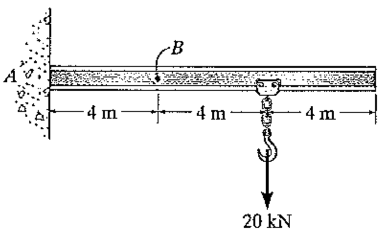
Prob. 6–24

6–25. A uniform live load of 7.5 kN/m and a single concentrated force of 90 kN are to be placed on the beam. Determine (a) the maximum positive live vertical reaction at support B, (b) the maximum positive live shear at point C, and (c) the maximum positive live moment at point C. Assume the support at A is a pin and B is a roller.



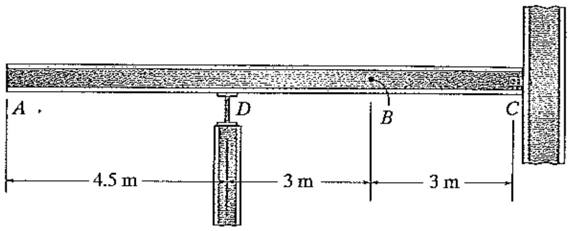
Prob. 6–25

6–26. The beam supports a uniform dead load of 0.8 kN/m and a single live concentrated force of 20 kN. Determine (a) the maximum negative moment that can be developed at A, and (b) the maximum positive shear that can be developed at point B.



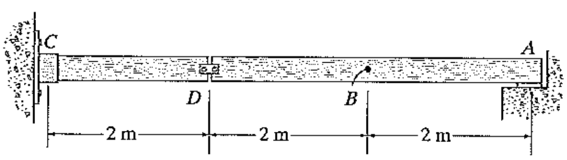
Prob. 6–26

6–27. The beam supports a uniform live load of 900 N/m and a live concentrated force of 900 N. Determine (a) the maximum positive live moment that can be developed at B, and (b) the maximum positive live vertical reaction at D. Assume C is a pin support and D is a roller.



Prob. 6–27

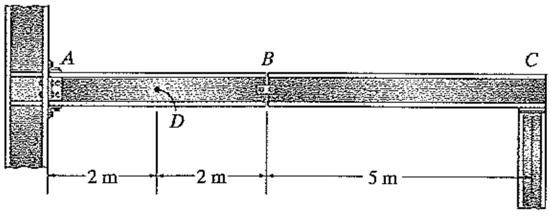
*6–28. The compound beam is subjected to a uniform dead load of 2 kN/m and a uniform live load of 1.5 kN/m. Determine (a) the maximum moment these loads develop at C, and (b) the maximum positive shear at B. Assume C is a fixed support, D is a pin, and A is a roller.



Prob. 6–28

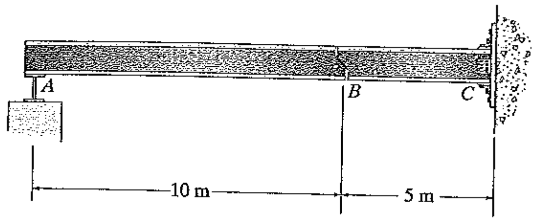
6–29. Where should a single 2-kN live load be placed on the beam so it causes the largest live moment at D? What is this moment? Assume the support at A is fixed, B is pinned, and C is a roller.

6–30. Where should the beam ABC be loaded with a 6 kN/m uniform distributed live load so it causes (a) the largest live moment at point A and (b) the largest live shear at D? Calculate the values of the moment and shear. Assume the support at A is fixed, B is pinned and C is a roller.



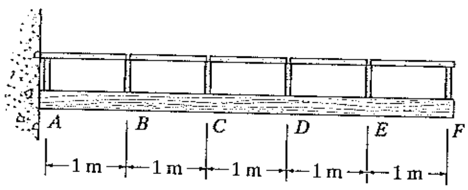
Probs. 6–29/6–30

6–31. The compound beam is subjected to a uniform dead load of 0.8 kN/m and a single concentrated live load of 4 kN. Determine (a) the maximum moment created by these loads at C, and (b) the maximum pin reaction at B. Assume A is a roller, B is a pin, and C is fixed.



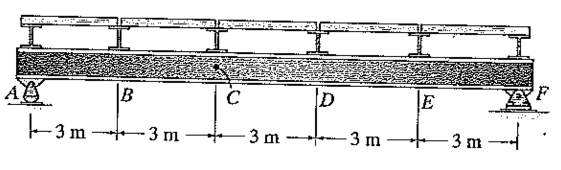
Prob. 6–31

*6–32. A uniform live load of 1.8 kN/m and a single concentrated live force of 4 kN are placed on the top beams. Determine (a) the maximum live shear in panel CB of the girder and (b) the maximum moment in the girder at C.



Prob. 6–32

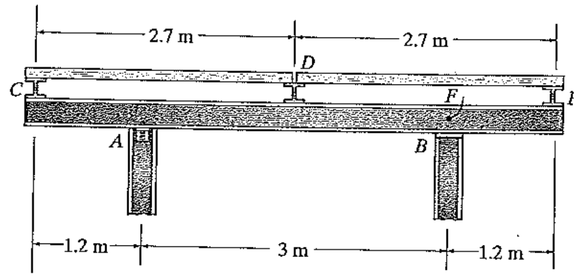
6–33. Draw the influence lines for (a) the shear in panel DE of the girder, and (b) the moment at C.



Prob. 6–33

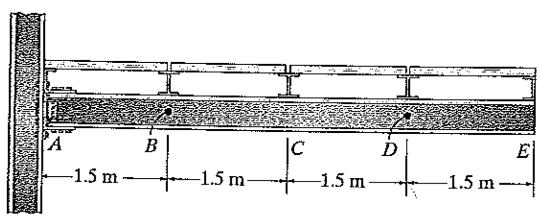
6–34. Draw the influence line for the moment at point F in the girder. Assume the support at A is a pin and B is a roller. Compute the maximum live moment at F in the girder if the floor slabs are subjected to a uniform distributed live load of 30 kN/m.

6–35. Draw the influence line for the shear in the end panel CA of the girder. Assume the support at A is a pin and B is a roller. Compute the maximum live shear in the girder region CA if the floor slabs are subjected to a uniform distributed load of 30 kN/m.



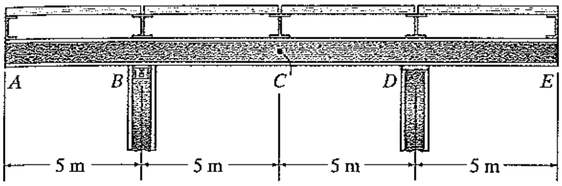
Probs. 6–34/6–35

*6–36. A uniform live load of 6 kN/m and a concentrated live force of 9 kN are to be placed on the floor slabs. Determine (a) the maximum live shear in panel CD, and (b) the maximum live moment at B.



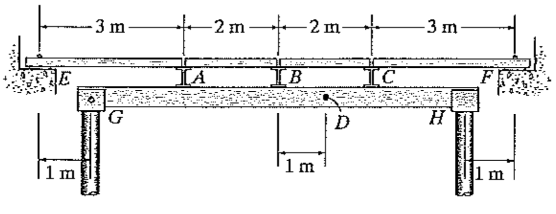
Prob. 6–36

6–37. Draw the influence line for (a) the shear in panel BC of the girder, and (b) the moment at C. Assume the support at B is a pin and D is a roller.



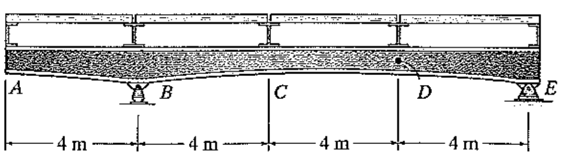
Prob. 6–37

6–38. A uniform live load of 5 kN/m and a single concentrated live force of 6 kN are to be placed on the floor beams. Determine (a) the maximum positive live shear in panel AB, and (b) the maximum live moment at D. Assume only vertical reaction occur at the supports.



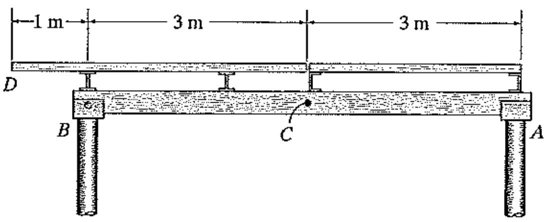
Prob. 6–38

6–39. Draw the influence lines for (a) the moment at D in the girder, and (b) the shear in panel BC.



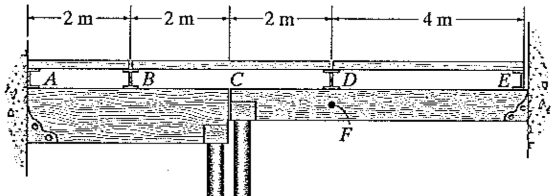
Prob. 6–39

***6–40.** A uniform live load of 15 kN/m and a single concentrated live force of 25 kN are to be placed on the top beams. Determine (a) the maximum positive live shear in panel BC of the girder, and (b) the maximum positive live moment at C. Assume the support at B is a roller and at D a pin.



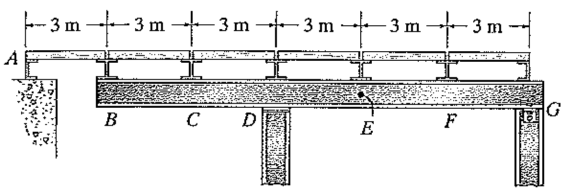
Prob. 6–40

6–41. Draw the influence line for the moment at F in the girder. Determine the maximum positive live moment in the girder at F if a single concentrated live force of 8 kN moves across the top floor beams. Assume the supports for all members can only exert either upward or downward forces on the members.



Prob. 6–41

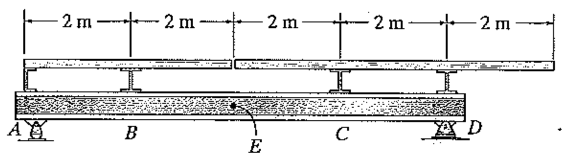
6–42. A uniform live load of 5 kN/m and a single concentrated live force of 18 kN are to be placed on the floor slabs. Determine (a) the maximum live vertical reaction at the support D, (b) the maximum live shear in panel DE of the girder, and (c) the maximum positive live moment at E. Assume D is a roller and G is a pin.



Prob. 6–42

6–43. Draw the influence line for the shear in panel CD of the girder. Determine the maximum negative live shear in panel CD due to a uniform live load of 10 kN/m acting on the top beams.

***6–44.** Draw the influence line for the moment at E in the girder. Determine the maximum positive live moment in the girder at E if a concentrated live force of 40 kN moves across the top beams.

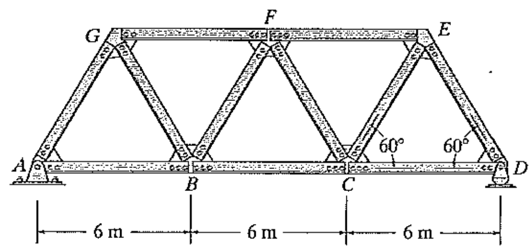


Probs. 6–43/6–44

6–45. Draw the influence line for the force in member BC of the Warren truss. Indicate numerical values for the peaks. All members have the same length. The load moves along the bottom cord.

6–46. Draw the influence line for the force in member BF of the Warren truss. Indicate numerical values for the peaks. All members have the same length. The load moves along the bottom cord.

6–47. Draw the influence line for the force in member FE of the Warren truss. Indicate numerical values for the peaks. All members have the same length. The load moves along the bottom cord.

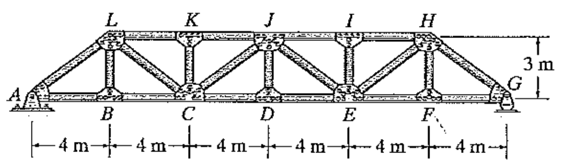


Probs. 6–45/6–46/6–47

***6–48.** Draw the influence line for the force in (a) member CJ, and (b) member DJ.

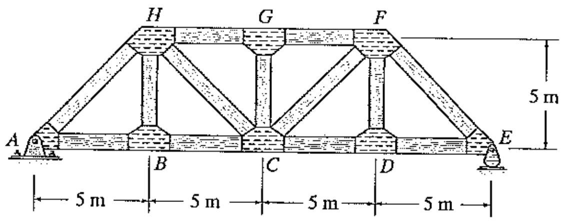
6–49. Draw the influence line for the force in member CD.

6–50. Draw the influence line for the force in member KJ.



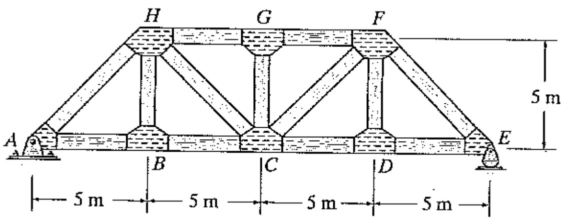
Probs. 6–48/6–49/6–50

6–51. Draw the influence line for the force in member CF, and then compute the maximum live force (tension or compression) that can be developed in this member due to a uniform live load of 16 kN/m which is transmitted to the truss along the bottom cord.



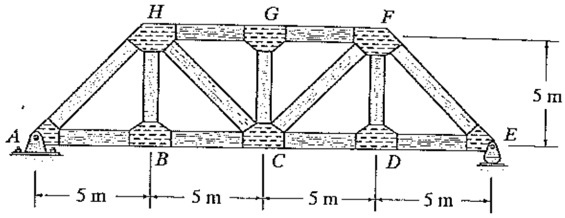
Prob. 6–51

***6–52.** Draw the influence line for the force in member CD, and then compute the maximum live force (tension or compression) that can be developed in this member due to a uniform live load of 16 kN/m. which is transmitted to the truss along the bottom cord.



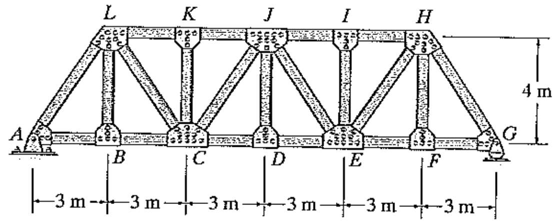
Prob. 6–52

6–53. Draw the influence line for the force in member GF, and then compute the maximum live force (tension or compression) that can be developed in this member due to a uniform live load of 16 kN/m which is transmitted to the truss along the bottom cord.



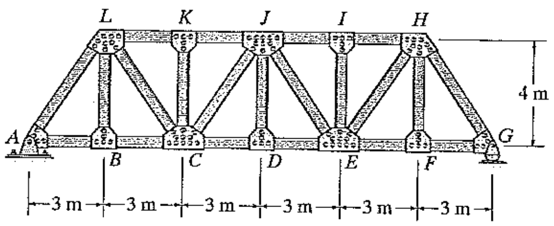
Prob. 6–53

6–54. Draw the influence line for the force in member KJ, then compute the maximum live force (tension or compression) that can be developed in this member due to a uniform live load of 3 kN/m which is transmitted to the truss along the bottom cord.



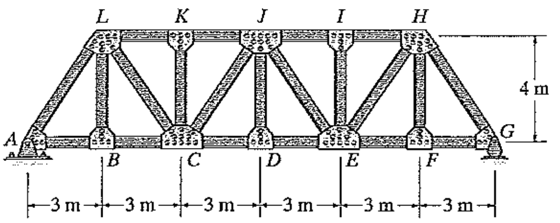
Prob. 6–54

6–55. Draw the influence line for the force in member CJ, then compute the maximum live force (tension or compression) that can be developed in this member due to a uniform live load of 3 kN/m which is transmitted to the truss along the bottom cord.



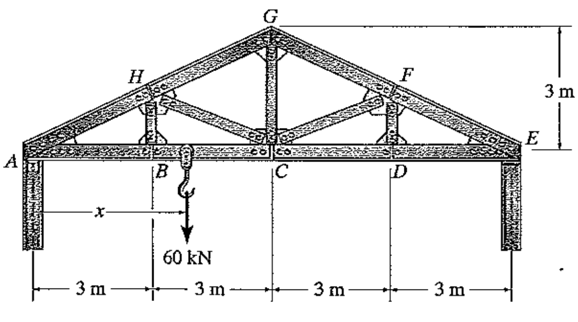
Prob. 6–55

*6–56. Draw the influence line for the force in member CD, then compute the maximum live force (tension or compression) that can be developed in this member due to a uniform live load of 3 kN/m which is transmitted to the truss along the bottom cord.



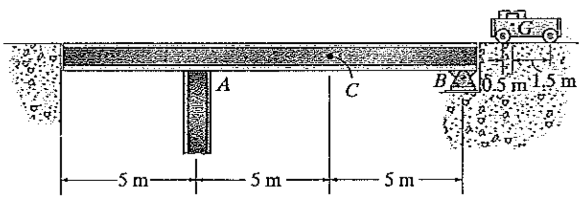
Prob. 6–56

6–57. The roof truss serves to support a crane rail which is attached to the bottom cord of the truss as shown. Determine the maximum live force (tension or compression) that can be developed in member GF, due to the crane load of 60 kN. Specify the position x of the load. Assume the truss is supported at A by a pin and at E by a roller. Also, assume all members are sectioned and pin-connected at the gusset plates.



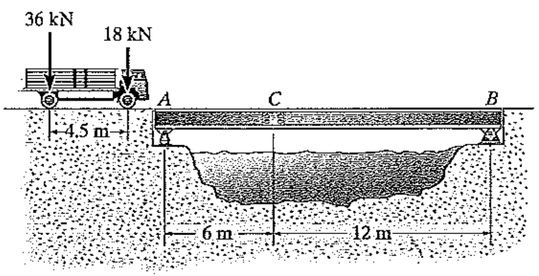
Prob. 6–57

6–58. Determine the maximum live moment at point C on the single girder caused by the moving dolly that has a mass of 2 Mg and a mass center at G. Assume A is a roller.



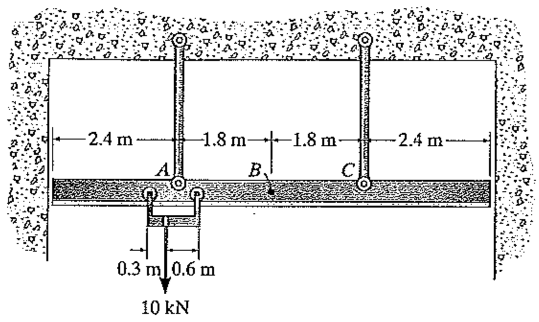
Prob. 6–58

6–59. The 54-kN truck exerts the wheel reactions shown on the deck of a girder bridge. Determine (a) the largest live shear it creates in the splice joint at C, and (b) the largest moment it exerts at the splice. Assume the truck travels in *either direction* along the *center* of the deck, and therefore transfers *half* of its load to each of the two side girders. Assume the splice is a fixed connection and like the girder it can support both shear and moment.



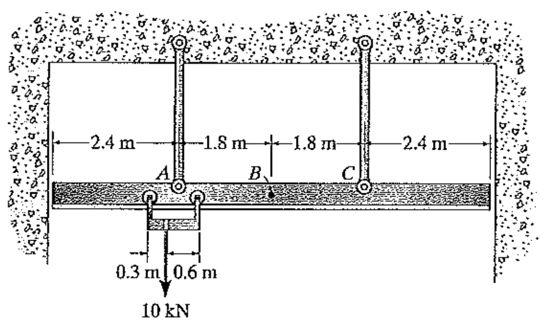
Prob. 6–59

*6–60. Determine the maximum live moment in the suspended rail at point B if the rail supports the load of 10 kN on the trolley.



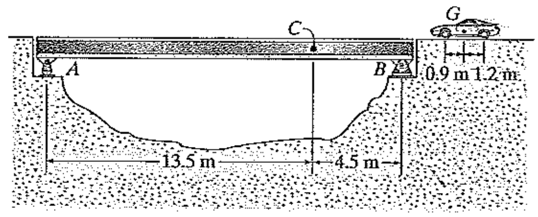
Prob. 6–60

6–61. Determine the maximum positive live shear at point B if the rail supports the load of 10 kN on the trolley.



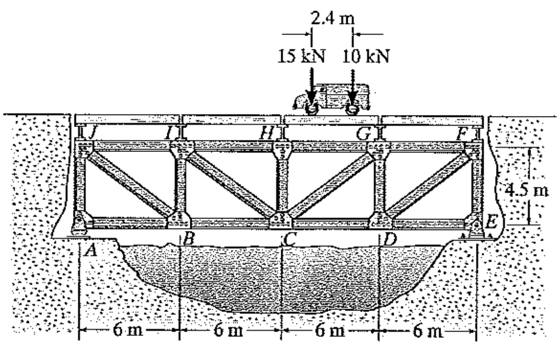
Prob. 6–61

6–62. The car has a weight of 21 kN and a center of gravity at G. Determine the maximum live moment created in the side girder at C as it crosses the bridge. Assume the car can travel in either direction along the *center* of the deck, so that *half* its load is transferred to each of the two side girders.



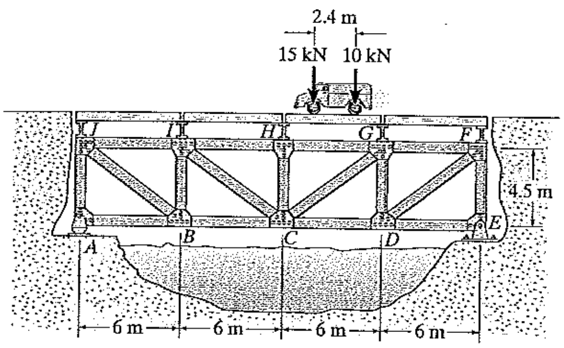
Prob. 6–62

6–63. Draw the influence line for the force in member BC of the bridge truss. Compute the maximum live force (tension or compression) that can be developed in the member due to a 25-kN truck having the wheel loads shown. Assume the truck can travel in *either direction* along the *center* of the deck, so that *half* the load shown is transferred to each of the two side trusses. Also assume the members are pin connected at the gusset plates.



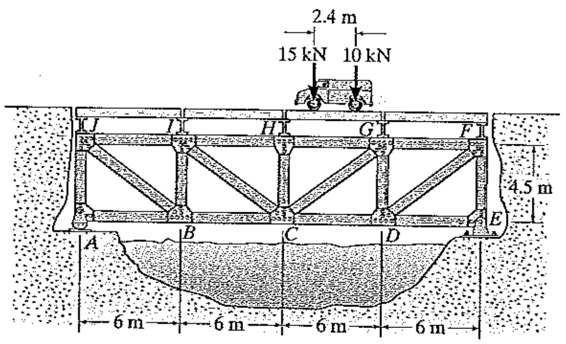
Prob. 6–63

*6–64. Draw the influence line for the force in member *IC* of the bridge truss. Compute the maximum live force (tension or compression) that can be developed in the member due to a 25-kN truck having the wheel loads shown. Assume the truck can travel in *either direction* along the *center* of the deck, so that half the load shown is transferred to each of the two side trusses. Also assume the members are pin connected at the gusset plates.



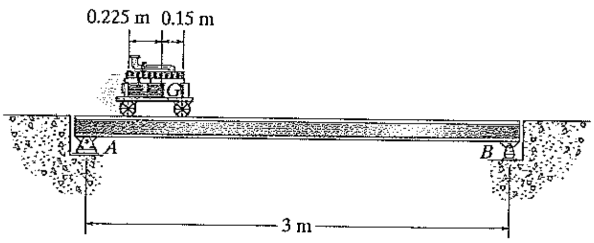
Prob. 6–64

6–65. Draw the influence line for the force in member *IH* of the bridge truss. Compute the maximum live force (tension or compression) that can be developed in the member due to a 25-kN truck having the wheel loads shown. Assume the truck can travel in *either direction* along the *center* of the deck, so that half the load shown is transferred to each of the two side trusses. Also assume the members are pin connected at the gusset plates.



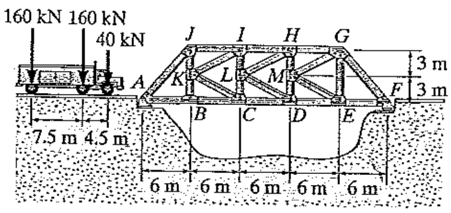
Prob. 6–65

6–66. The machine has a weight of 20 kN and a mass center at *G*. Determine the maximum moment it produces in the single girder.



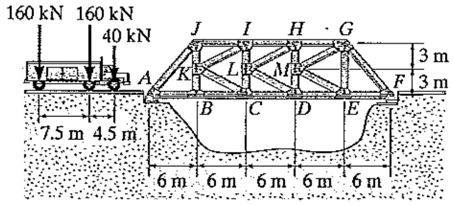
Prob. 6–66

6–67. Draw the influence line for the force in member *IH* of the bridge truss. Compute the maximum live force (tension or compression) that can be developed in this member due to a 360-kN truck having the wheel loads shown. Assume the truck can travel in *either direction* along the *center* of the deck, so that half its load is transferred to each of the two side trusses. Also assume the members are pin connected at the gusset plates.



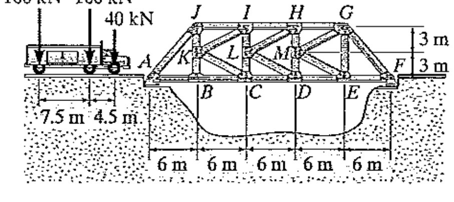
Prob. 6–67

*6–68. Draw the influence line for the force in member CD of the bridge truss. Compute the maximum live force (tension or compression) that can be developed in this member due to a 360-kN truck having the wheel loads shown. Assume the truck can travel in *either direction* along the *center* of the deck, so that *half* its load is transferred to each of the two side trusses. Also assume the members are pin connected at the gusset plates.



Prob. 6–68

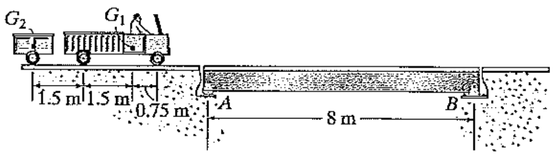
6–69. Draw the influence line for the force in member BC for the bridge truss. Compute the maximum live force (tension or compression) that can be developed in this member due to the 360-kN truck having the wheel loads shown. Assume the truck can travel in *either direction* along the *center* of the deck, so that *half* its load is transferred to each of the two side trusses. Also assume the members are pin connected at the gusset plates.



Prob. 6–69

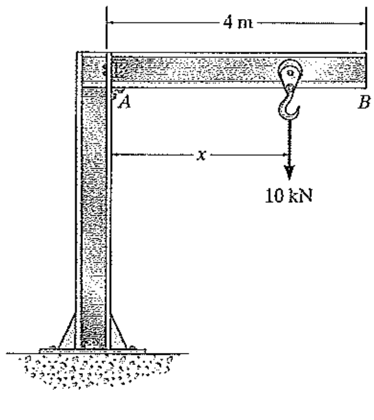
6–70. The truck has a mass of 4 Mg and mass center at G_1, and the trailer has a mass of 1 Mg and mass center at G_2. Determine the absolute maximum live moment developed in the bridge.

6–71. Determine the absolute maximum live moment in the bridge in Problem 6–70 if the trailer is removed.



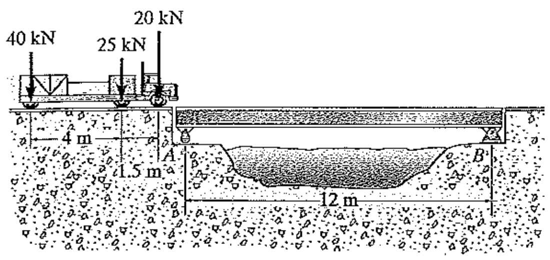
Probs. 6–70/6–71

*6–72. Determine the absolute maximum live shear and absolute maximum live moment in the jib beam AB due to the 10-kN loading. The end constraints require $0.1 \text{ m} \leq x \leq 3.9 \text{ m}$.



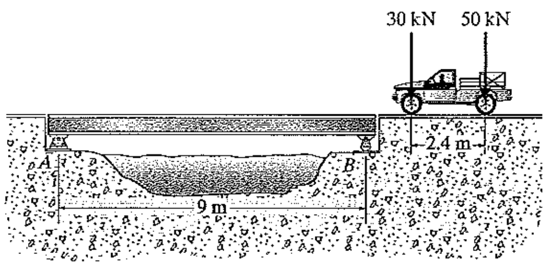
Prob. 6–72

6–73. Determine the absolute maximum live moment in the bridge due to the loading shown.



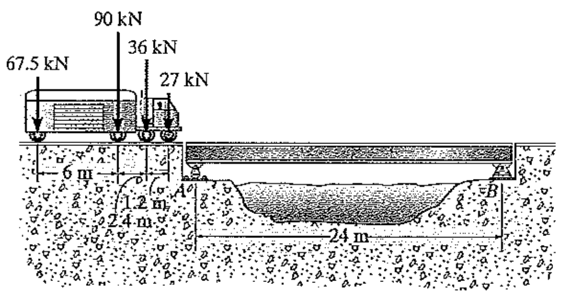
Prob. 6–73

6–74. Determine the absolute maximum live moment in the bridge due to the loading shown.



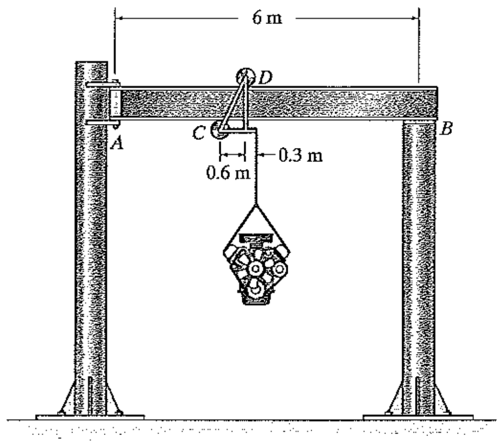
Prob. 6–74

6–75. Determine the absolute maximum live moment in the bridge due to the truck loading shown.



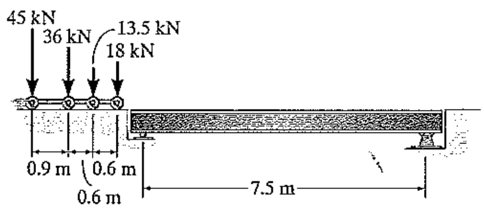
Prob. 6–75

***6–76.** The trolley rolls at C and D along the bottom and top flange of beam AB. Determine the absolute maximum live moment developed in the beam if the load supported by the trolley is 12 kN. Assume the support at A is a pin and at B a roller.



Prob. 6–76

6–77. Determine the absolute maximum live moment in the girder due to the loading shown.

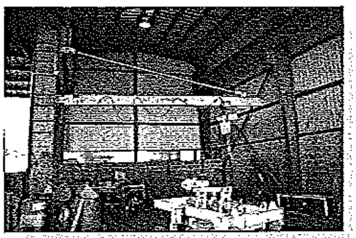


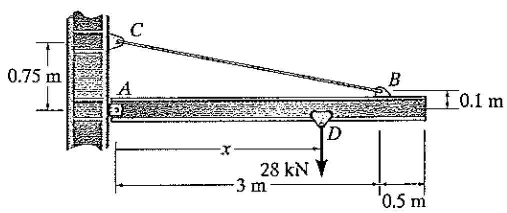
Prob. 6–77

PROJECT PROBLEMS

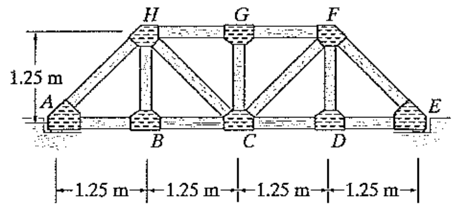
6–1P. The chain hoist on the wall crane can be placed anywhere along the boom ($0.1 \text{ m} < x < 3.4 \text{ m}$) and has a rated capacity of 28 kN. Use an impact factor of 0.3 and determine the absolute maximum bending moment in the boom and the maximum force developed in the tie rod BC. The boom is pinned to the wall column at its left end A. Neglect the size of the trolley at D.

6–2P. A simply supported pedestrian bridge is to be constructed in a city park and two designs have been proposed as shown in case a and case b. The truss members are to be made from timber. The deck consists of 1.5-m-long planks that have a mass of 20 kg/m^2. A local code states the live load on the deck is required to be 5 kPa with an impact factor of 0.2. Consider the deck to be simply supported on stringers. Floor beams then transmit the load to the bottom joints of the truss. (See Fig. 6–23.) In each case find the member subjected to the largest tension and largest compression load and suggest why you would choose one design over the other. Neglect the weights of the truss members.

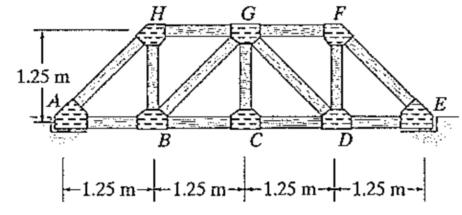




Prob. 6–1P



case a



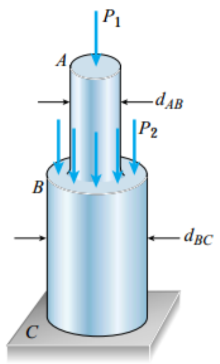
case b

Prob. 6–2P

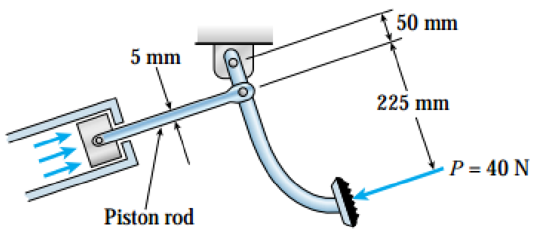
1.1. A solid circular post *ABC* (see figure) supports a load P_1 = 11.000 N acting at the top. A second load P_2 is uniformly distributed around the shelf at *B*. The diameters of the upper and lower parts of the post are d_{AB} = 32 mm. and d_{BC}= 60 mm., respectively.

a. Calculate the normal stress σ_{AB} in the upper part of the post.

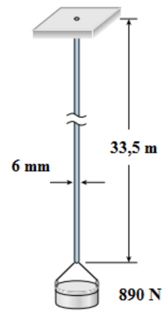
b. If it is desired that the lower part of the post have the same compressive stress as the upper part, what should be the magnitude of the load P_2?



1.2. Calculate the compressive stress σ_c in the circular piston rod (see figure) when a force *P* = 40 N is applied to the brake pedal. Assume that the line of action of the force *P* is parallel to the piston rod, which has diameter 5 mm. Also, the other dimensions shown in the figure (50 mm and 225 mm) are measured perpendicular to the line of action of the force *P*.



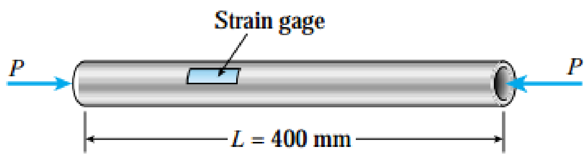
1.3. A steel rod 33,5 m long hangs inside a tall tower and holds a 890 N weight at its lower end (see figure). If the diameter of the circular rod is 6 mm, calculate the maximum normal stress σ_{max} in the rod, taking into account the weight of the rod itself. (γ_{steel} = 77 kN/m^3)



1.4. A circular aluminum tube of length *L* = 400 mm is loaded in compression by forces *P* (see figure). The outside and inside diameters are 60 mm and 50 mm, respectively. A strain gage is placed on the outside of the bar to measure normal strains in the longitudinal direction.

a. If the measured strain is $\varepsilon = 550\times 10^{-6}$, what is the shortening d of the bar?

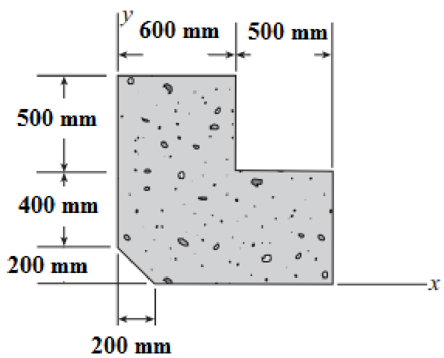
b. If the compressive stress in the bar is intended to be 40 MPa, what should be the load *P*?



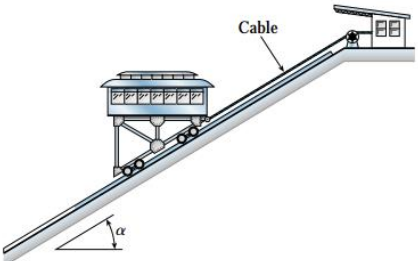
1.5. The cross section of a concrete corner column that is loaded uniformly in compression is shown in the figure.

a. Determine the average compressive stress σ_c in the concrete if the load is equal to 14.250 kN.

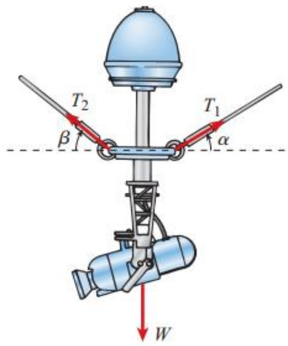
b. Determine the coordinates x_c and y_c of the point where the resultant load must act in order to produce uniform normal stress in the column.



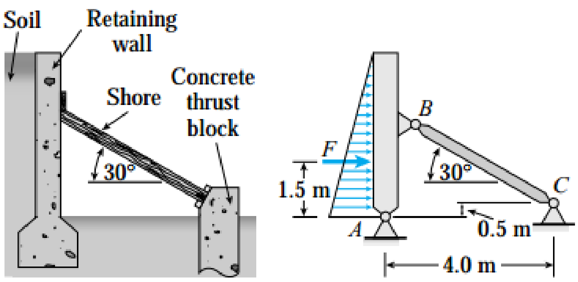
1.6. A car weighing 130 kN when fully loaded is pulled slowly up a steep inclined track by a steel cable (see figure). The cable has an effective cross-sectional area of 490 mm^2, and the angle a of the incline is 30°. Calculate the tensile stress σ_t in the cable.



1.7. Two steel wires support a moveable overhead camera weighing W = 110 N (see figure) used for close-up viewing of field action at sporting events. At some instant, wire 1 is at an angle α = 20° to the horizontal and wire 2 is at an angle β = 48°. Both wires have a diameter of 0,75 mm. Determine the tensile stresses σ_1 and σ_2 in the two wires.



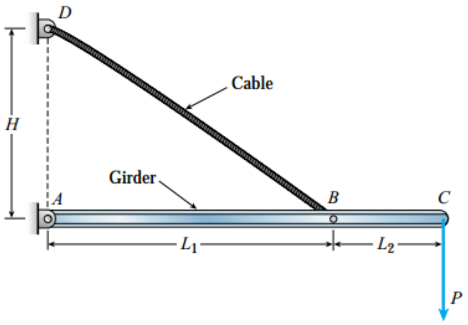
1.8. A long retaining wall is braced by wood shores set at an angle of 30° and supported by concrete thrust blocks, as shown in the first part of the figure. The shores are evenly spaced, 3 m apart. For analysis purposes, the wall and shores are idealized as shown in the second part of the figure. Note that the base of the wall and both ends of the shores are assumed to be pinned. The pressure of the soil against the wall is assumed to be triangularly distributed, and the resultant force acting on a 3-meter length of the wall is F = 190 kN. If each shore has a 150 mm × 150 mm square cross section, what is the compressive stress σ_c in the shores?



1.9. A loading crane consisting of a steel girder ABC supported by a cable BD is subjected to a load P (see the figure). The cable has an effective crosssectional area A = 481 mm^2. The dimensions of the crane are H = 1,6 m, L_1 = 3 m, and L_2 = 1,5 m.

a. If the load P = 32 kN, what is the average tensile stress in the cable?

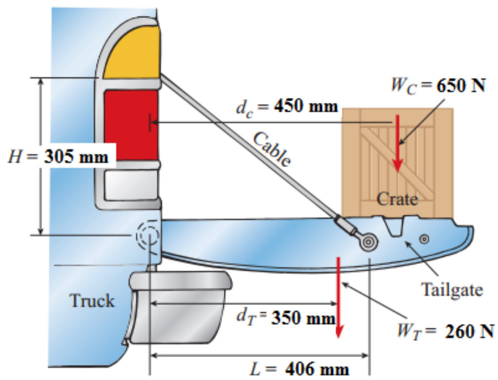
b. If the cable stretches by 5,1 mm., what is the average strain?



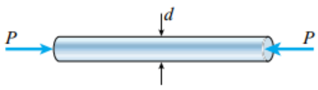
1.10. A pickup truck tailgate supports a crate (W_C = 650 N), as shown in the figure. The tailgate weighs W_T = 260 N and is supported by two cables (only one is shown in the figure). Each cable has an effective cross sectional area A_e = 11 mm^2.

a. Find the tensile force T and normal stress σ in each cable.

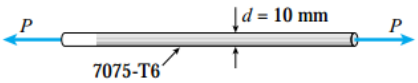
b. If each cable elongates δ = 0.25 mm. due to the weight of both the crate and the tailgate, what is the average strain in the cable?



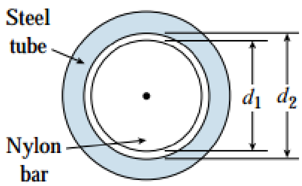
1.11. A high-strength steel bar used in a large crane has diameter d = 50 mm. (see figure). The steel has modulus of elasticity E = 200 GPa and Poisson's ratio ν = 0.29. Because of clearance requirements, the diameter of the bar is limited to 50,825 mm. when it is compressed by axial forces. What is the largest compressive load P_{max} that is permitted?



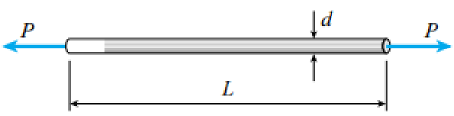
1.12. A round bar of 10 mm diameter is made of aluminum alloy 7075-T6 (see figure). When the bar is stretched by axial forces P, its diameter decreases by 0.016 mm. Find the magnitude of the load P. (E = 72 GPa, ν = 0.33, Yield stress σ_Y = 480 MPa)



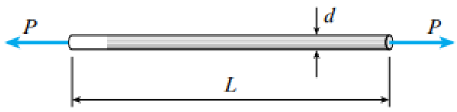
1.13. A nylon bar having diameter d_1 = 90 mm. is placed inside a steel tube having inner diameter d_2 = 89,2 mm. (see figure). The nylon bar is then compressed by an axial force P. At what value of the force P will the space between the nylon bar and the steel tube be closed? (For nylon, assume E = 2.750 MPa and ν = 0.4.)



1.14. A prismatic bar of circular cross section is loaded by tensile forces P (see figure). The bar has length L = 1.5 m and diameter d = 30 mm. It is made of aluminum alloy with modulus of elasticity E = 75 GPa and Poisson's ratio ν = 1/3. If the bar elongates by 3.6 mm, what is the decrease in diameter d? What is the magnitude of the load P?

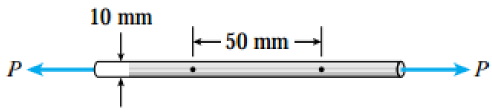


1.15. A bar of monel metal (length L = 200 mm., diameter d = 6,5 mm.) is loaded axially by a tensile force P = 6.500 N (see figure). Using E = 172 GPa and ν = 0,32, determine the increase in length of the bar and the percent decrease in its cross-sectional area.



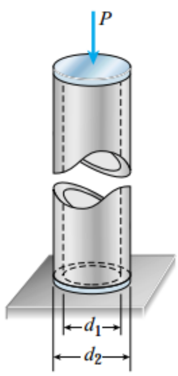
1.16. A tensile test is peformed on a brass specimen 10 mm in diameter using a gage length of 50 mm (see figure). When the tensile load P reaches a value of 20 kN, the distance between the gage marks has increased by 0.122 mm.

a. What is the modulus of elasticity E of the brass?
b. If the diameter decreases by 0.00830 mm, what is Poisson's ratio?

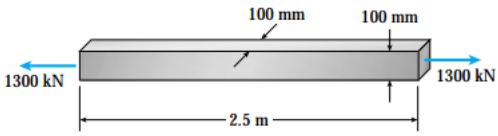


1.17. A hollow steel cylinder is compressed by a force P (see figure). The cylinder has inner diameter d_1 = 100 mm., outer diameter d_2 = 115 mm., and modulus of elasticity E = 205 GPa. When the force P increases from zero to 180 kN, the outer diameter of the cylinder increases by $11,6 \times 10^{-3}$ mm.

a. Determine the increase in the inner diameter.
b. Determine the increase in the wall thickness.
c. Determine Poisson's ratio for the steel.

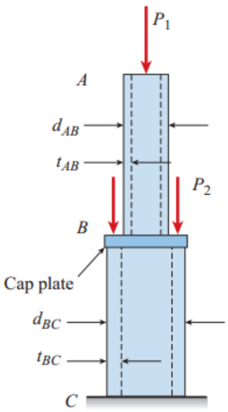


1.18. A steel bar of length 2.5 m with a square cross section 100 mm on each side is subjected to an axial tensile force of 1300 kN (see figure). Assume that E = 200 GPa and ν = 0.3. Determine the increase in volume of the bar.

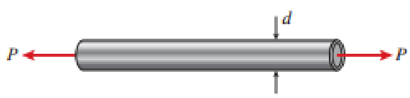


1.19. A hollow, brass circular pipe ABC (see figure) supports a load P_1 = 120 kN acting at the top. A second load P_2 = 98 kN is uniformly distributed around the cap plate at B. The diameters and thicknesses of the upper and lower parts of the pipe are d_{AB} = 32 mm., t_{AB} = 12,5 mm., d_{BC} = 58 mm., and t_{BC} = 9,5 mm., respectively. The modulus of elasticity is 96 GPa. When both loads are fully applied, the wall thickness of pipe BC increases by 5×10^{-3}mm.

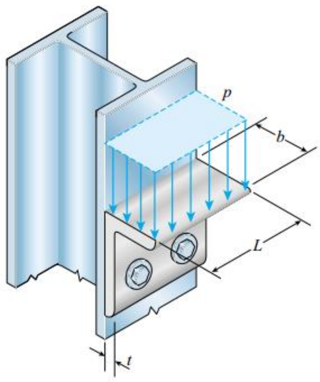
a. Find the increase in the inner diameter of pipe segment BC.
b. Find Poisson's ratio for the brass.
c. Find the increase in the wall thickness of pipe segment AB and the increase in the inner diameter of AB.



1.20. An aluminum bar (E 70 GPa, ν 0.33) of diameter 20 mm is stretched by axial forces P, causing its diameter to decrease by 0.022 mm. Find the load P.

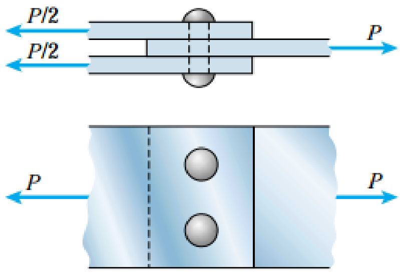


1.21. An angle bracket having thickness t = 12 mm. Is attached to the flange of a column by two 16 mm diameter bolts (see figure). A uniformly distributed load acts on the top face of the bracket with a pressure p = 2 MPa. The top face of the bracket has length L = 150 mm. and width b = 65 mm. Determine the average bearing pressure σ_b between the angle bracket and the bolts and the average shear stress τ_{aver} in the bolts. (Disregard friction between the bracket and the column.)



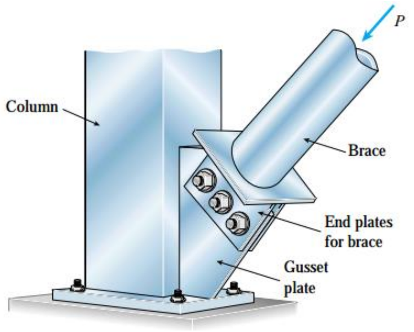
1.22. Three steel plates, each 16 mm thick, are joined by two 20-mm diameter rivets as shown in the figure.

a. If the load P = 50 kN, what is the largest bearing stress acting on the rivets?
b. If the ultimate shear stress for the rivets is 180 MPa, what force P_{ult} is required to cause the rivets to fail in shear? (Disregard friction between the plates.)



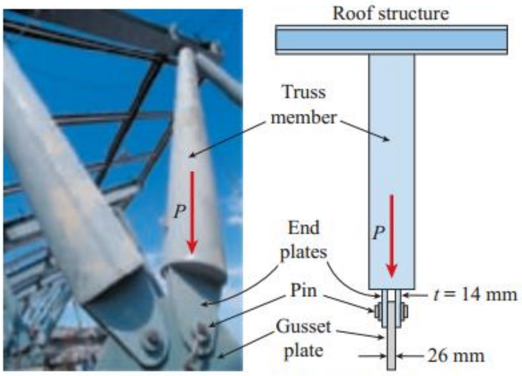
1.23. A bolted connection between a vertical column and a diagonal brace is shown in the figure on the next page. The connection consists of three 5/8-in. bolts that join two 1/4-in.end plates welded to the brace and a 5/8-in. gusset plate welded to the column. The compressive load P carried by the brace equals 8.0 k. Determine the following quantities:

a. The average shear stress τ_{aver} in the bolts, and
b. the average bearing stress σ_b between the gusset plate and the bolts. (Disregardfriction between the plates.)



1.24. Truss members supporting a roof are connected to a 26-mm-thick gusset plate by a 22 mm diameter pin as shown in the figure and photo. The two end plates on the truss members are each 14 mm thick.

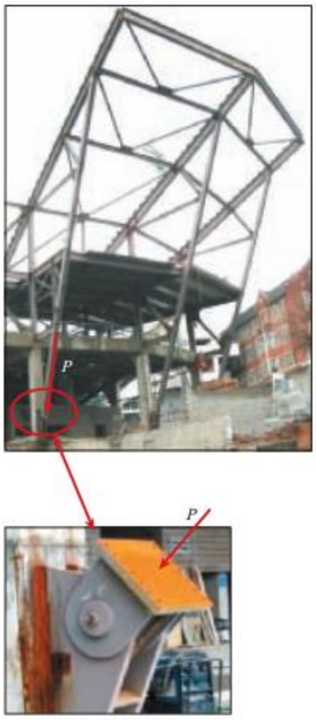
a. If the load P = 80 kN, what is the largest bearing stress acting on the pin?
b. If the ultimate shear stress for the pin is 190 MPa, what force P_{ult} is required to cause the pin to fail in shear? (Disregard friction between the plates.)



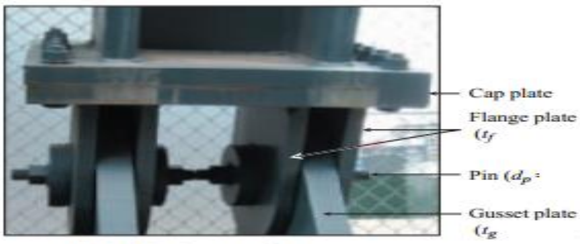
Truss members supporting a roof (Vince Streano/Getty Images)

1.25. The upper deck of a football stadium is supported by braces each of which transfers a load P = 710 kN to the base of a column [see figure part (a)]. A cap plate at the bottom of the brace distributes the load P to four flange plates (t_f = 25 mm.) through a pin (d_p = 50 mm.) to two gusset plates (t_g = 1.5 in.) [see figure parts (b) and (c)]. Determine the following quantities

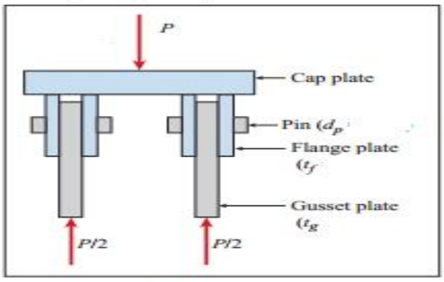
a. The average shear stress τ_{aver} in the pin
b. The average bearing stress between the flange plates and the pin (σ_{bf}), and also between the gusset plates and the pin (σ_{bg}). (Disregard friction between the plates.)



(a) Stadium brace

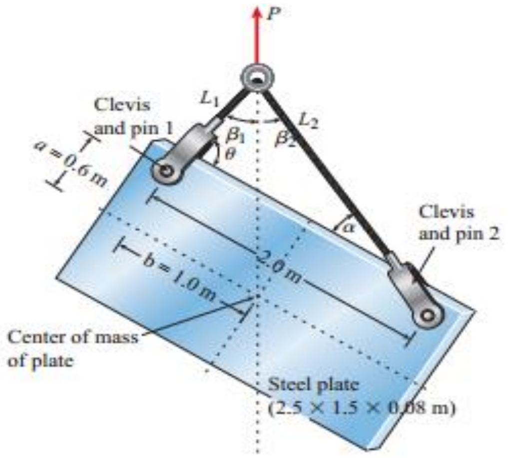


(b) Detail at bottom of brace
(© Barry Goodno)



(c) Section through bottom of brace
(© Barry Goodno)

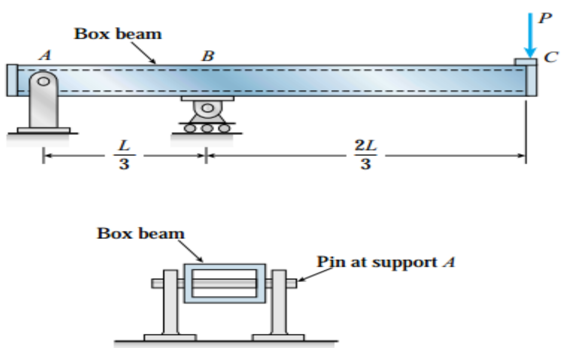
1.26. A steel plate of dimensions 2.5×1.5×0.08 m and weighing 23.1 kN is hoisted by steel cables with lengths L_1 = 3.2 m and L_2 = 3.9 m that are each attached to the plate by a clevis and pin (see figure). The pins through the clevises are 18 mm in diameter and are located 2.0 m apart. The orientation angles are measured to be θ = 94.4° and α = 54.9°. For these conditions, first determine the cable forces T_1 and T_2, then find the average shear stress τ_{aver} in both pin 1 and pin 2, and then the average bearing stress σ_b between the steel plate and each pin. Ignore the mass of the cables.



1.27. A hollow box beam *ABC* of length *L* is supported at end *A* by a 20-mm diameter pin that passes through the beam and its supporting pedestals (see figure). The roller support at *B* is located at distance *L*/3 from end *A*.

a. Determine the average shear stress in the pin due to a load *P* equal to 10 kN.

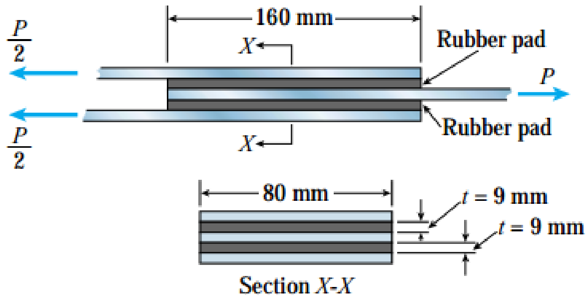
b. Determine the average bearing stress between the pin and the box beam if the wall thickness of the beam is equal to 12 mm.



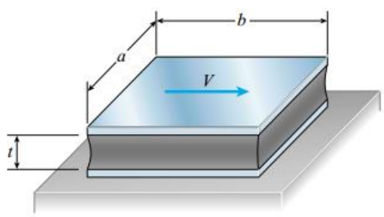
1.28. A flexible connection consisting of rubber pads (thickness *t* = 9 mm) bonded to steel plates is shown in the figure. The pads are 160 mm long and 80 mm wide.

a. Find the average shear strain γ_{aver} in the rubber if the force *P* = 16 kN and the shear modulus for the rubber is *G* = 1250 kPa.

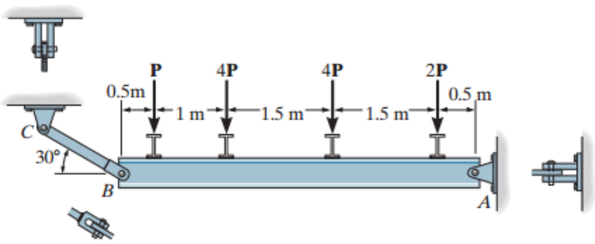
b. Find the relative horizontal displacement δ between the interior plate and the outer plates.



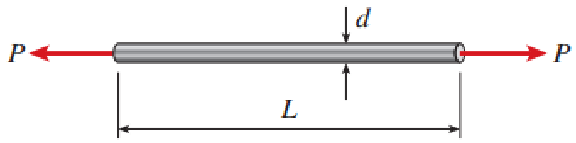
1.29. An elastomeric bearing pad consisting of two steel plates bonded to a chloroprene elastomer (an artificial rubber) is subjected to a shear force *V* during a static loading test (see figure). The pad has dimensions *a* = 150 mm and *b* = 250 mm, and the elastomer has thickness *t* = 50 mm. When the force *V* equals 12 kN, the top plate is found to have displaced laterally 8.0 mm with respect to the bottom plate. What is the shear modulus of elasticity *G* of the chloroprene?



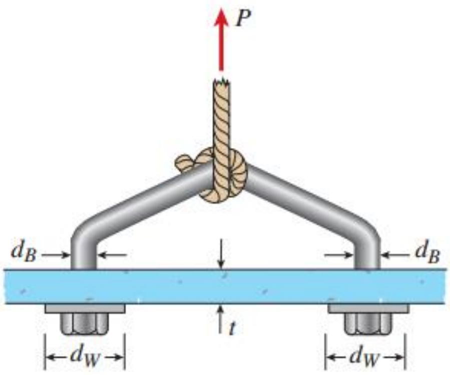
1.30. The beam is supported by a pin at A and a short link BC. If P = 15 kN, determine the average shear stress developed in the pins at A, B, and C. All pins are in double shear as shown, and each has a diameter of 18 mm.



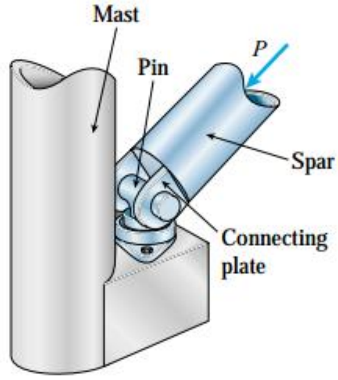
1.31. A bar of solid circular cross section is loaded in tension by forces P (see figure). The bar has length L = 380 mm and diameter d = 6 mm. The material is a magnesium alloy having modulus of elasticity E = 42.7 GPa. The allowable stress in tension is sallow 89.6 GPa and the elongation of the bar must not exceed 0.08 mm.



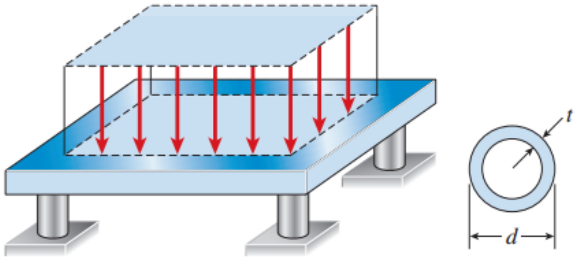
1.32. A tie-down on the deck of a sailboat consists of a bent bar bolted at both ends, as shown in the figure. The diameter d_B of the bar is 6 mm, the diameter d_W of the washers is 22 mm, and the thickness t of the fiberglass deck is 10 mm. If the allowable shear stress in the fiberglass is 2.1 MPa, and the allowable bearing pressure between the washer and the fiberglass is 3.8 MPa, what is the allowable load P_{allow} on the tie-down?



1.33. A ship's spar is attached at the base of a mast by a pin connection (see figure on the next page). The spar is a steel tube of outer diameter d_2 = 80 mm and inner diameter d_1 = 70 mm. The steel pin has diameter d = 25 mm, and the two plates connecting the spar to the pin have thickness t = 12 mm. The allowable stresses are as follows: compressive stress in the spar, 70 MPa; shear stress in the pin, 45 MPa; and bearing stress between the pin and the connecting plates, 110 MPa. Determine the allowable compressive force P_{allow} in the spar.



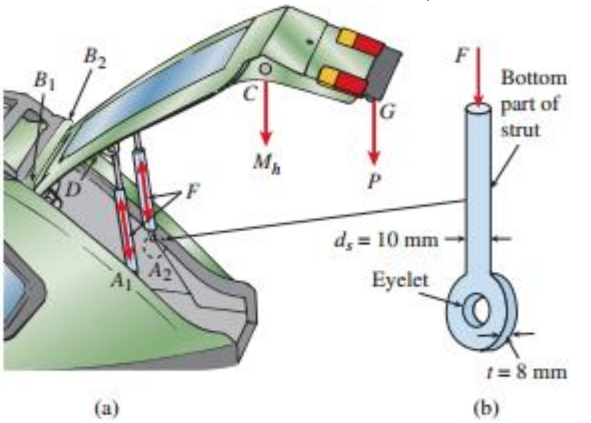
1.34. A steel pad supporting heavy machinery rests on four short, hollow, cast iron piers (see figure). The ultimate strength of the cast iron in compression is 344.5 MPa. The outer diameter of the piers is d 114 mm and the wall thickness is t 10 mm. Using a factor of safety of 4.0 with respect to the ultimate strength, determine the total load P that may be supported by the pad.

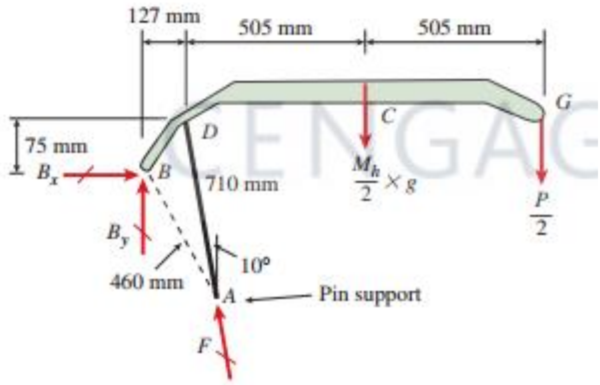


1.35. The rear hatch of a van [*BDCF* in figure part (a)] is supported by two hinges at *B*1 and *B*2 and by two struts *A*1*B*1 and *A*2*B*2 (diameter *ds* 10 mm) as shown in figure part (b). The struts are supported at *A*1 and *A*2 by pins, each with diameter d_p = 9 mm and passing through an eyelet of thickness t = 8 mm at the end of the strut [figure part (b)]. If a closing force P 50 N is applied at *G* and the mass of the hatch *Mh* 43 kg is concentrated at *C*:

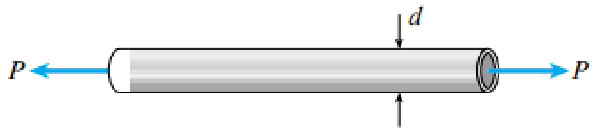
a. What is the force F in each strut? [Use the freebody diagram of one half of the hatch in the figure part (c)]

b. What is the maximum permissible force in the strut, Fallow, if the allowable stresses are as follows: compressive stress in the strut, 70 MPa; shear stress in the pin, 45 MPa; and bearing stress between the pin and the end of the strut, 110 MPa

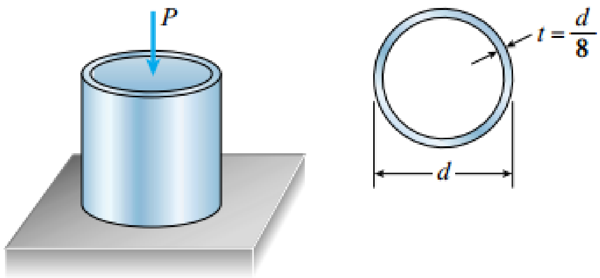




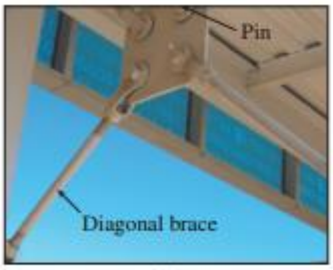
1.36. An aluminum tube is required to transmit an axial tensile force P 148 kN [see figure]. The thickness of the wall of the tube is to be 6 mm. What is the minimum required outer diameter d_{min} if the allowable tensile stress is 84 MPa?



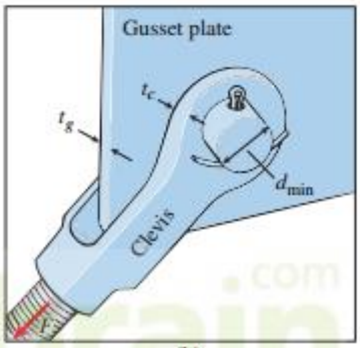
1.37. A steel pipe having yield stress σy = 270 MPa is to carry an axial compressive load P = 1200 kN (see figure). A factor of safety of 1.8 against yielding is to be used. If the thickness t of the pipe is to be one-eighth of its outer diameter, what is the minimum required outer diameter d_{min}?



1.38. Lateral bracing for an elevated pedestrian walkway is shown in the figure part (a). The thickness of the clevis plate t_c = 16 mm and the thickness of the gusset plate t_g= 20 mm [see figure part (b)]. The maximum force in the diagonal bracing is expected to be F 190 kN. If the allowable shear stress in the pin is 90 MPa and the allowable bearing stress between the pin and both the clevis and gusset plates is 150 MPa, what is the minimum required diameter $d$min of the pin?

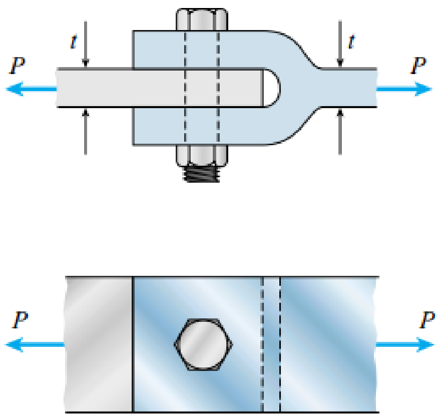


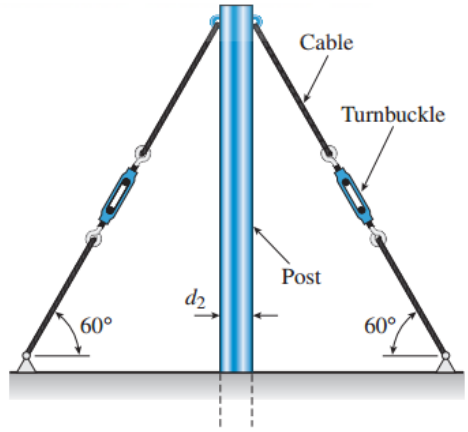
(a)
(© Barry Goodno)



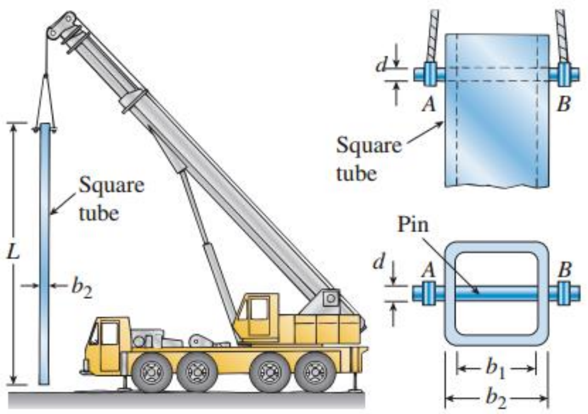
(b)

1.39. Two bars of rectangular cross section (thickness t 15 mm) are connected by a bolt in the manner shown in the figure. The allowable shear stress in the bolt is 90 MPa and the allowable bearing stress between the bolt and the bars is 150 MPa. If the tensile load P = 31 kN, what is the minimum required diameter d_{min} of the bolt?





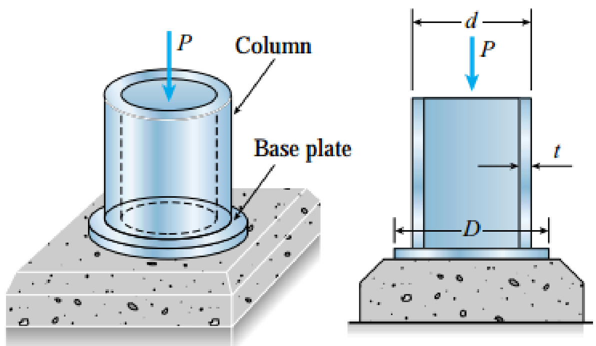
1.40. A square steel tube of length *L* 6 m and width *b*2 250 mm is hoisted by a crane (see figure). The tube hangs from a pin of diameter *d* that is held by the cables at points *A* and *B*. The cross section is a hollow square with inner dimension b_1 = 210 mm and outer dimension b_2 = 250 mm. The allowable shear stress in the pin is 60 MPa, and the allowable bearing stress between the pin and the tube is 90 MPa. Determine the minimum diameter of the pin in order to support the weight of the tube. (*Note:* Disregard the rounded corners of the tube when calculating its weight.)



1.41. A tubular post of outer diameter d_2 is guyed by two cables fitted with turnbuckles (see figure). The cables are tightened by rotating the turnbuckles, thus producing tension in the cables and compression in the post. Both cables are tightened to a tensile force of 110 kN. Also, the angle between the cables and the ground is 60°, and the allowable compressive stress in the post is σ_c 35 MPa. If the wall thickness of the post is 15 mm, what is the minimum permissible value of the outer diameter d_2?

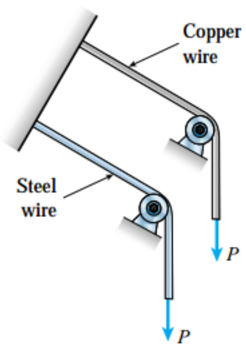
1.42. A steel column of hollow circular cross section is supported on a circular steel base plate and a concrete pedestal (see figure). The column has outside diameter *d* = 250 mm and supports a load *P* = 750 kN.

a. If the allowable stress in the column is 55 MPa, what is the minimum required thickness *t*? Based upon your result, select a thickness for the column. (Select a thickness that is an even integer, such as 10, 12, 14, . . ., in units of millimeters.)
b. If the allowable bearing stress on the concrete pedestal is 11.5 MPa, what is the minimum required diameter*D* of the base plate if it is designed for the allowable load P_{allow} that the column with the selected thickness can support?



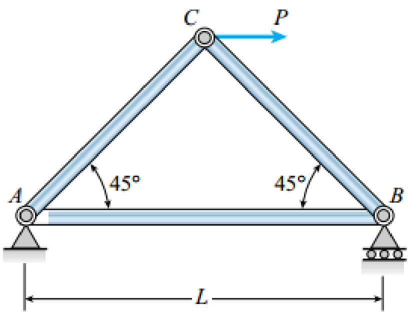
1.43. A steel cable with nominal diameter 25 mm (A = 304 mm^2) is used in a construction yard to lift a bridge section weighing 38 kN, as shown in the figure. The cable has an effective modulus of elasticity *E* = 140 GPa. If the cable is 14 m long, how much will it stretch when the load is picked up?If the cable is rated for a maximum load of 70 kN, what is the factor of safety with respect to failure of the cable?

1.44. A steel wire and a copper wire have equal lengths and support equal loads P (see figure). The moduli of elasticity for the steel and copper are E_s = 205 GPa and E_c = 125 GPa, respectively. (a) If the wires have the same diameters, what is the ratio of the elongation of the copper wire to the elongation of the steel wire? (b) If the wires stretch the same amount, what is the ratio of the diameter of the copper wire to the diameter of the steel wire?



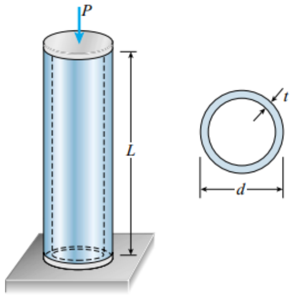
1.45. The three-bar truss *ABC* shown in the figure has a span L = 3 m and is constructed of steel pipes having cross-sectional area A = 3900 mm^2 and modulus of elasticity E = 200 GPa. A load P act horizontally to the right at joint*C*.

a. If P = 650 kN, what is the horizontal displacement of joint*B*?
b. What is the maximum permissible load Pmax if the displacement of joint *B* is limited to 1.5 mm?

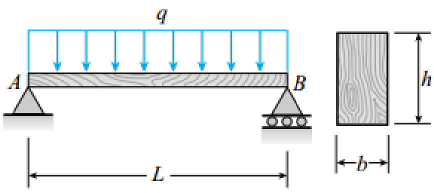


1.46. An aluminum wire having a diameter d = 2 mm and length L = 3.8 m is subjected to a tensile load P. The aluminum has modulus of elasticity E = 75 GPa. If the maximum permissible elongation of the wire is 3.0 mm and the allowable stress in tension is 60 MPa, whatis the allowable load P_{max}?

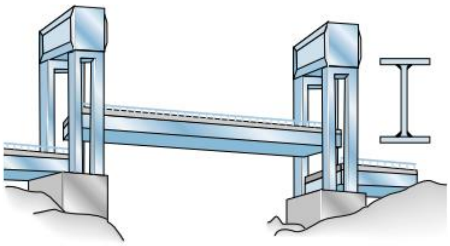
1.47. A hollow, circular, steel column (E = 205 GPa) is subjected to a compressive load P, as shown in the figure. The column has length L = 2,4 m and outside diameter d = 190 mm. The load P = 380 kN. If the allowable compressive stress is 48 MPa and the allowable shortening of the column is 0.5 mm., what is the minimum required wall thickness t_{min}?



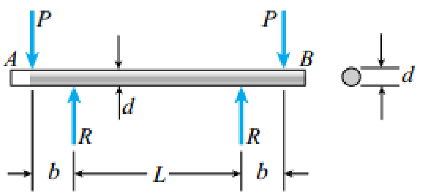
2.1. A simply supported wood beam *AB* with span length L = 3.5 m carries a uniform load of intensity q = 6.4 kN/m (see figure). Calculate the maximum bending stress smax due to the load q if the beam has a rectangular cross section with width b = 140 mm and height h = 240 mm.



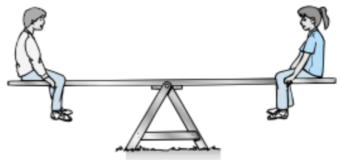
2.2. Each girder of the lift bridge (see figure) is 55 m long and simply supported at the ends. The design load for each girder is a uniform load of intensity 25 kN/m. The girders are fabricated by welding three steel plates so as to form an I-shaped cross section (see figure) having section modulus S = 58,99·10^6 mm^3. What is the maximum bending stress σ_{max} in a girder due to the uniform load?



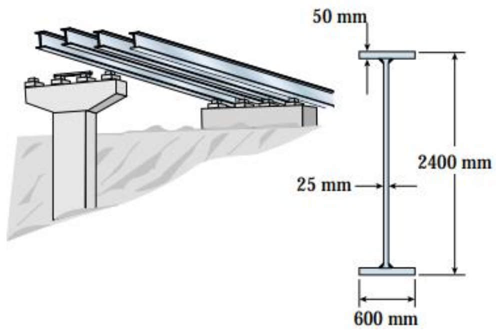
2.3. A freight-car axle *AB* is loaded approximately as shown in the figure, with the forces P representing the car loads (transmitted to the axle through the axle boxes) and the forces R representing the rail loads (transmitted to the axle through the wheels). The diameter of the axle is d = 80 mm, the distance between centers of the rails is L, and the distance between the forces P and R is b = 200 mm. Calculate the maximum bending stress smax in the axle if P = 47 kN.



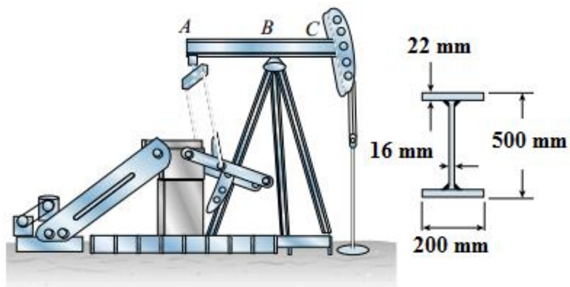
2.4. A seesaw weighing 45 N/m of length is occupied by two children, each weighing 400 N (see figure). The center of gravity of each child is 2,4 m from the fulcrum. The board is 5,8 m long, 200 mm. wide, and 40 mm. thick. What is the maximum bending stress in the board?



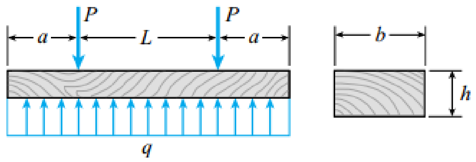
2.5. During construction of a highway bridge, the main girders are cantilevered outward from one pier toward the next (see figure). Each girder has a cantilever length of 46 m and an I-shaped cross section with dimensions as shown in the figure. The load on each girder (during construction) is assumed to be 11.0 kN/m, which includes the weight of the girder. Determine the maximum bending stress in a girder due to this load.



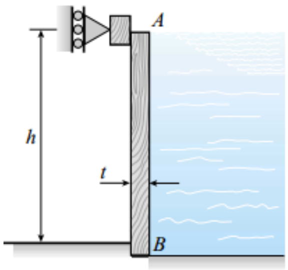
2.6. The horizontal beam *ABC* of an oil-well pump has the cross section shown in the figure. If the vertical pumping force acting at end C is 40 kN, and if the distance from the line of action of that force to point B is 4,25 m, what is the maximum bending stress in the beam due to the pumping force?



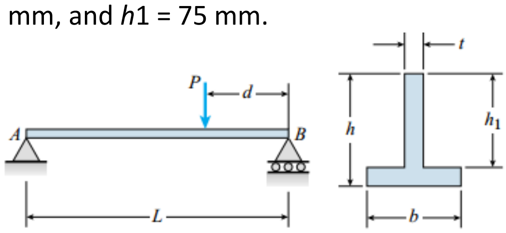
2.7. A railroad tie (or *sleeper*) is subjected to two rail loads, each of magnitude P = 175 kN, acting as shown in the figure. The reaction q of the ballast is assumed to be uniformly distributed over the length of the tie, which has cross-sectional dimensions b = 300 mm and h = 250 mm. Calculate the maximum bending stress smax in the tie due to the loads P, assuming the distance L = 1500 mm and the overhang length a = 500 mm.



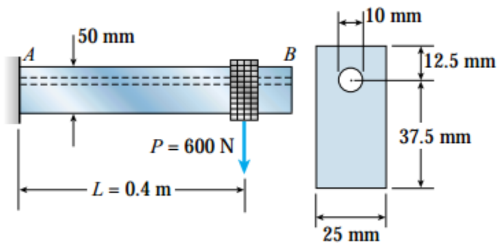
2.8. A small dam of height h = 2.0 m is constructed of vertical wood beams AB of thickness t = 120 mm, as shown in the figure. Consider the beams to be simply supported at the top and bottom. Determine the maximum bending stress σ_{max} in the beams, assuming that the weight density of water is g = 9.81 kN/m^3.



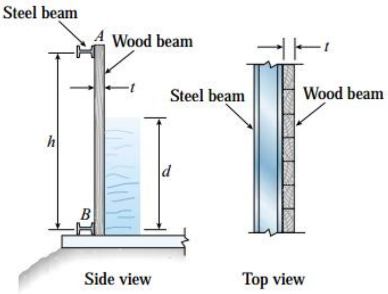
2.9. Determine the maximum tensile stress τ and maximum compressive stress σ_c due to the load P acting on the simple beam AB (see figure). Data are as follows: P = 5.4 kN, L = 3.0 m, d = 1.2 m, b = 75 mm, t = 25 mm, h = 100 mm, and $h1$ = 75 mm.



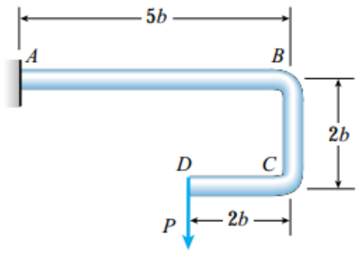
2.10. A cantilever beam AB with a rectangular cross section has a longitudinal hole drilled throughout its length (see figure). The beam supports a load P = 600 N. The cross section is 25 mm wide and 50 mm high, and the hole has a diameter of 10 mm. Find the bending stresses at the top of the beam, at the top of the hole, and at the bottom of the beam.



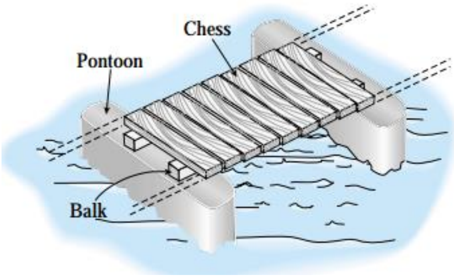
2.11. A small dam of height h = 1,8 m is constructed of vertical wood beams AB, as shown in the figure. The wood beams, which have thickness t = 60 mm., are simply supported by horizontal steel beams at A and B. Construct a graph showing the maximum bending stress σ_{max} in the wood beams versus the depth d of the water above the lower support at B. Plot the stress σ_{max} (MPa) as the ordinate and the depth d (m) as the abscissa. (*Note:* The weight density g of water equals 10 kN/m^3.)



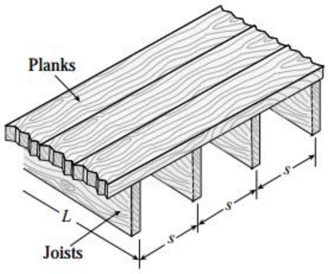
2.12. A fiberglass bracket $ABCD$ of solid circular cross section has the shape and dimensions shown in the figure. A vertical load P = 36 N acts at the free end D. Determine the minimum permissible diameter $d$min of the bracket if the allowable bending stress in the material is 30 MPa and b = 35 mm. (Disregard the weight of the bracket itself.)



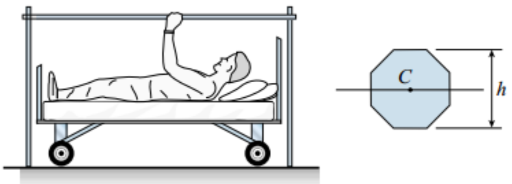
2.13. A pontoon bridge (see figure) is constructed of two longitudinal wood beams, known as *balks*, that span between adjacent pontoons and support the transverse floor beams, which are called *chesses*. For purposes of design, assume that a uniform floor load of 8.0 kPa acts over the chesses. (This load includes an allowance for the weights of the chesses and balks.) Also, assume that the chesses are 2.0 m long and that the balks are simply supported with a span of 3.0 m. The allowable bending stress in the wood is 16 MPa. If the balks have a square cross section, what is their minimum required width $b$min?



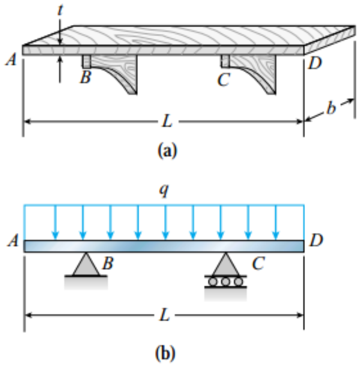
2.14. The wood joists supporting a plank floor (see figure) are 40 mm × 180 mm in cross section (actual dimensions) and have a span length L = 4.0 m. The floor load is 3.6 kPa, which includes the weight of the joists and the floor. Calculate the maximum permissible spacing s of the joists if the allowable bending stress is 15 MPa. (Assume that each joist may be represented as a simple beam carrying a uniform load.)



2.15. A so-called "trapeze bar" in a hospital room provides a means for patients to exercise while in bed (see figure). The bar is 2.1 m long and has a cross section in the shape of a regular octagon. The design load is 1.2 kN applied at the midpoint of the bar, and the allowable bending stress is 200 MPa. Determine the minimum height h of the bar. (Assume that the ends of the bar are simply supported and that the weight of the bar is negligible.)

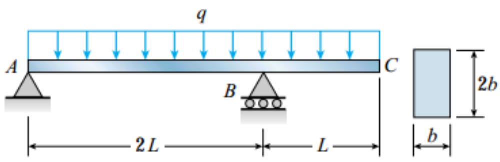


2.16. A horizontal shelf AD of length L = 900 mm, width b = 300 mm, and thickness t = 20 mm is supported by brackets at B and C [see part (a) of the figure]. The brackets are adjustable and may be placed in any desired positions between the ends of the shelf. A uniform load of intensity q, which includes the weight of the shelf itself, acts on the shelf [see part (b) of the figure]. Determine the maximum permissible value of the load q if the allowable bending stress in the shelf is σ_{allow} = 5.0 MPa and the position of the supports is adjusted for maximum load-carrying capacity.

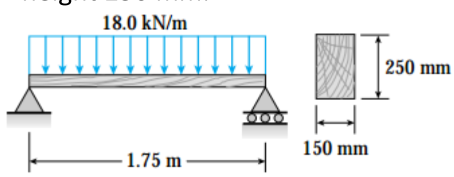


2.17. A steel beam ABC is simply supported at A and B and has an overhang BC of length L =150 mm (see figure on the next page). The beam supports a uniform load of intensity q = 3.5 kN/m over its entire length of 450 mm. The cross section of the beam is rectangular with width b and height $2b$. The allowable bending stress in the steel is σ_{allow} = 60 MPa and its weight density is $\gamma = 77.0$ kN/m^3.

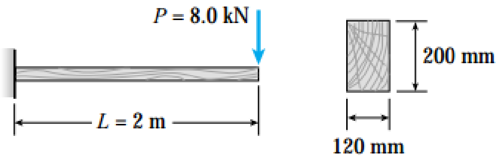
a. Disregarding the weight of the beam, calculate the required width b of the rectangular cross section.
b. Taking into account the weight of the beam, calculate the required width b.



2.18. Calculate the maximum shear stress τ_{max} and the maximum bending stress σ_{max} in a simply supported wood beam (see figure) carrying a uniform load of 18.0 kN/m (which includes the weight of the beam) if the length is 1.75 m and the cross section is rectangular with width 150 mm and height 250 mm.

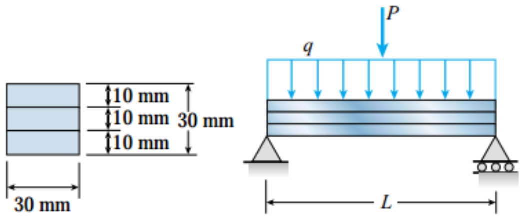


2.19. A cantilever beam of length L = 2 m supports a load P = 8.0 kN (see figure). The beam is made of wood with cross-sectional dimensions 120 mm × 200 mm. Calculate the shear stresses due to the load P at points located 25 mm, 50 mm, 75 mm, and 100 mm from the top surface of the beam. From these results, plot a graph showing the distribution of shear stresses from top to bottom of the beam.

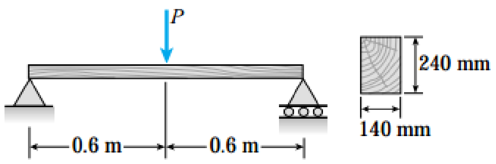


2.20. A laminated plastic beam of square cross section is built up by gluing together three strips, each 10 mm × 30 mm in cross section (see figure). The beam has a total weight of 3.2 N and is simply supported with span length L = 320 mm. Considering the weight of the beam, calculate the maximum permissible load P that may be placed at the midpoint if

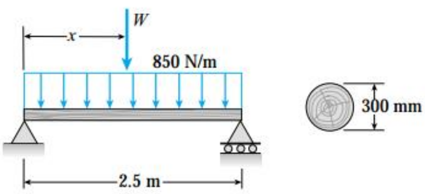
a. the allowable shear stress in the glued joints is 0.3 MPa, and
b. the allowable bending stress in the plastic is 8 MPa



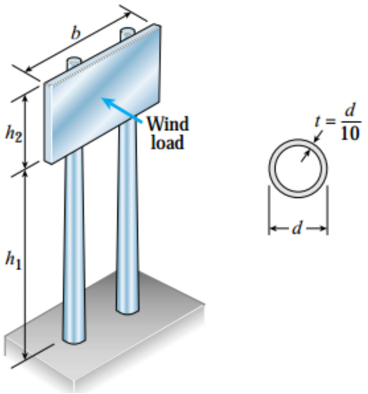
2.21. A simply supported wood beam of rectangular cross section and span length 1.2 m carries a concentrated load P at midspan in addition to its own weight (see figure). The cross section has width 140 mm and height 240 mm. The weight density of the wood is 5.4 kN/m^3. Calculate the maximum permissible value of the load P if (a) the allowable bending stress is 8.5 MPa, and (b) the allowable shear stress is 0.8 MPa.



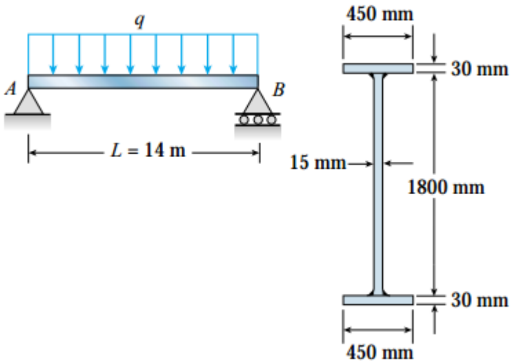
2.22. A simple log bridge in a remote area consists of two parallel logs with planks across them (see figure). The logs are Douglas fir with average diameter 300 mm. A truck moves slowly across the bridge, which spans 2.5 m. Assume that the weight of the truck is equally distributed between the two logs. Because the wheelbase of the truck is greater than 2.5 m, only one set of wheels is on the bridge at a time. Thus, the wheel load on one log is equivalent to a concentrated load W acting at any position along the span. In addition, the weight of one log and the planks it supports is equivalent to a uniform load of 850 N/m acting on the log. Determine the maximum permissible wheel load W based upon (a) an allowable bending stress of 7.0 MPa, and (b) an allowable shear stress of 0.75 MPa.



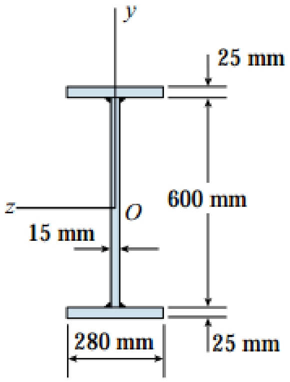
2.23. A sign for an automobile service station is supported by two aluminum poles of hollow circular cross section, as shown in the figure. The poles are being designed to resist a wind pressure of 3,6 kPa against the full area of the sign. The dimensions of the poles and sign are h_1 = 6,0 m, h_2 = 1,5 m, and b = 3m. To prevent buckling of the walls of the poles, the thickness t is specified as one-tenth the outside diameter d. (a) Determine the minimum required diameter of the poles based upon an allowable bending stress of 50 MPa in the aluminum. (b) Determine the minimum required diameter based upon an allowable shear stress of 14 MPa.



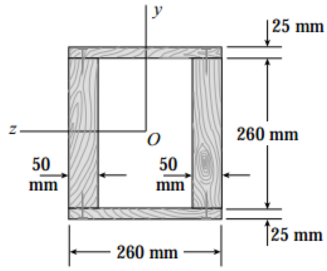
2.24. A bridge girder *AB* on a simple span of length L = 14 m supports a uniform load of intensity q that includes the weight of the girder (see figure). The girder is constructed of three plates welded to form the cross section shown. Determine the maximum permissible load q based upon (a) an allowable bending stress σ_{allow} = 110 MPa, and (b) an allowable shear stress τ_{allow} = 50 MPa.



2.25. A welded steel girder having the cross section shown in the figure is fabricated of two 280 mm × 25 mm flange plates and a 600 mm × 15 mm web plate. The plates are joined by four fillet welds that run continuously for the length of the girder. Each weld has an allowable load in shear of 900 kN/m. Calculate the maximum allowable shear force V max for the girder.

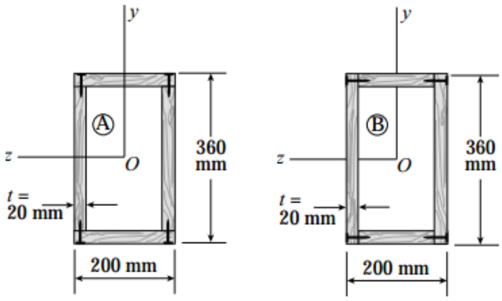


2.26. A box beam of wood is constructed of two 260 mm × 50 mm boards and two 260 mm × 25 mm boards (see figure). The boards are nailed at a longitudinal spacing s = 100 mm. If each nail has an allowable shear force F =1200 N, what is the maximum allowable shear force V max?

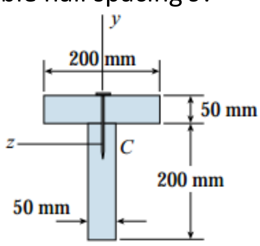


2.27. Two wood box beams (beams *A* and *B*) have the same outside dimensions (200 mm × 360 mm) and the same thickness (t = 20 mm) throughout, as shown in the figure on the next page. Both beams are formed by nailing, with each nail having an allowable shear load of 250 N. The beams are designed for a shear force V = 3.2 kN.

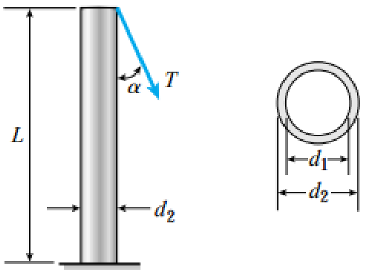
a. What is the maximum longitudinal spacing s_A for the nails in beam *A*?
b. What is the maximum longitudinal spacing s_B for the nails in beam *B*?
c. Which beam is more efficient in resisting the shear force?



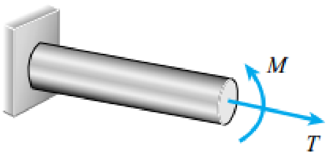
2.28. A beam of T cross section is formed by nailing together two boards having the dimensions shown in the figure. If the total shear force V acting on the cross section is 1600 N and each nail may carry 750 N in shear, what is the maximum allowable nail spacing s?



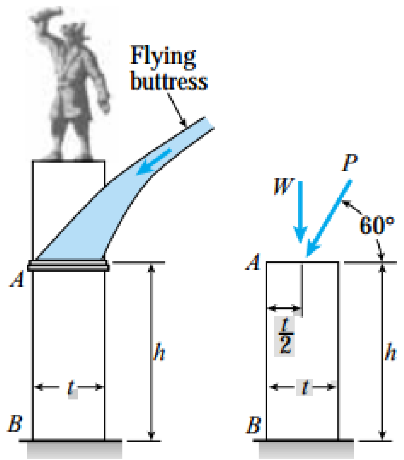
2.29. A vertical pole of aluminum is fixed at the base and pulled at the top by a cable having a tensile force T (see figure). The cable is attached at the outer surface of the pole and makes an angle α = 25° at the point of attachment. The pole has length L = 2.0 m and a hollow circular cross section with outer diameter d_2 = 260 mm and inner diameter d_1 = 200 mm. Determine the allowable tensile force T_{allow} in the cable if the allowable compressive stress in the aluminum pole is 90 MPa.



2.30. A steel bar of solid circular cross section is subjected to an axial tensile force T = 26 kN and a bending moment M = 3.2 kN·m (see figure). Based upon an allowable stress in tension of 120 MPa, determine the required diameter d of the bar. (Disregard the weight of the bar itself.)



2.31. A flying buttress transmits a load P = 25 kN, acting at an angle of 60° to the horizontal, to the top of a vertical buttress AB (see figure). The vertical buttress has height h = 5.0 m and rectangular cross section of thickness t = 1.5 m and width b = 1.0 m (perpendicular to the plane of the figure). The stone used in the construction weighs γ = 26 kN/m^3. What is the required weight W of the pedestal and statue above the vertical buttress (that is, above section A) to avoid any tensile stresses in the vertical buttress?



2.32. A plain concrete wall (i.e., a wall with no steel reinforcement) rests on a secure foundation and serves as a small dam on a creek (see figure on the next page). The height of the wall is h = 1,8 m and the thickness of the wall is t = 300 mm.

a. (a) Determine the maximum tensile and compressive stresses σ_t and σ_c, respectively, at the base of the wall when the water level reaches the top (d = h). Assume plain concrete has weight density γ_c = 22 kN/m^3.

b. Determine the maximum permissible depth d_{max} of the water if there is to be no tension in the concrete.