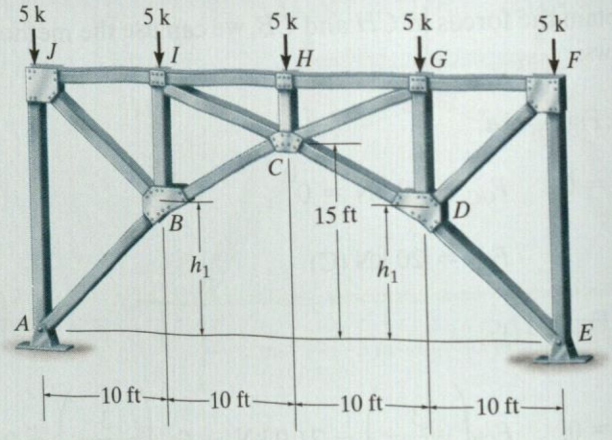
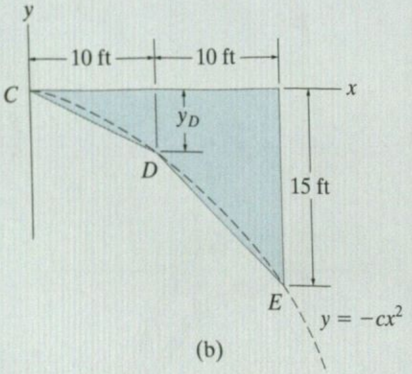
EXAMPLE 5.6

The three-hinged trussed arch shown in Fig. 5–12a supports the symmetric loading. Determine the required height h_1 of the joints B and D, so that the arch takes a funicular shape. Member HG is intended to carry no force.



(a)



(b)

Fig. 5–12

SOLUTION

For a symmetric loading, the funicular shape for the arch must be *parabolic* as indicated by the dashed line (Fig. 5–12b). Here we must find the equation which fits this shape. With the x, y axes having an origin at C, the equation is of the form $y = -cx^2$. To obtain the constant c, we require

$$-(15\text{ ft}) = -c(20\text{ ft})^2$$

$$c = 0.0375/\text{ft}$$

Therefore,

$$y_D = -(0.0375/\text{ft})(10\text{ ft})^2 = -3.75\text{ ft}$$

So that from Fig. 5–12a,

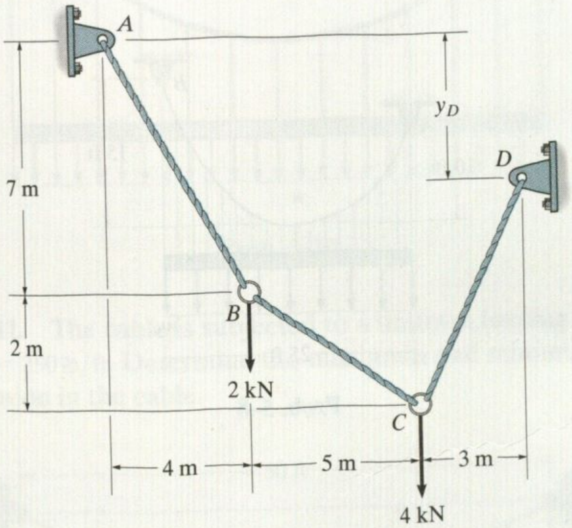
$$h_1 = 15\text{ ft} - 3.75\text{ ft} = 11.25\text{ ft} \qquad \textit{Ans.}$$

Using this value, if the method of joints is now applied to the truss, the results will show that the top cord and diagonal members will all be zero-force members, and the symmetric loading will be supported *only by the bottom cord* members AB, BC, CD, and DE of the truss.

PROBLEMS

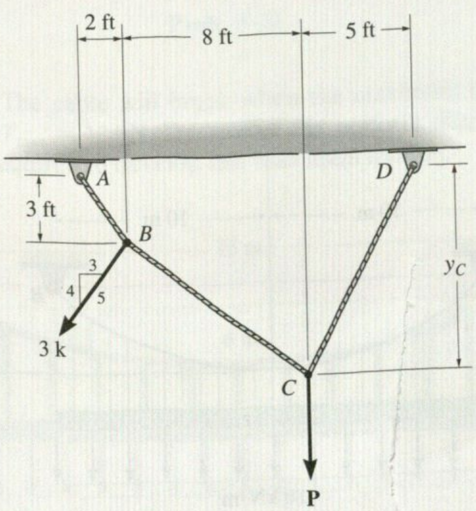
Sec. 5.1–5.2

5–1. Determine the tension in each segment of the cable and the distance y_D.



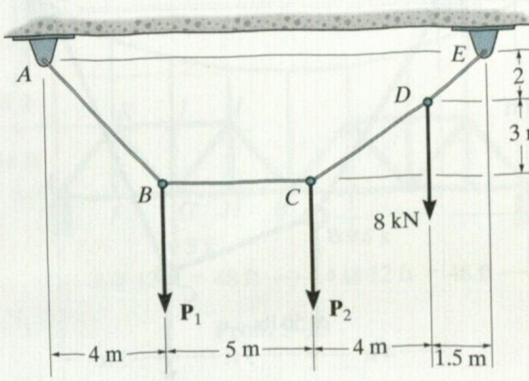
Prob. 5–1

5–2. The cable supports the loading shown. Determine the magnitude of the vertical force **P** so that $y_C = 6$ ft.



Prob. 5–2

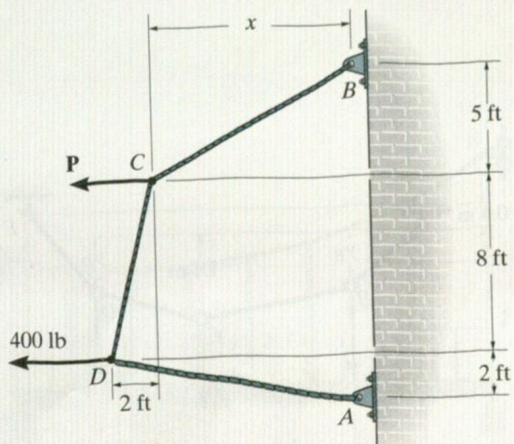
5–3. Determine the forces P_1 and P_2 needed to hold the cable in the position shown, i.e., so segment BC remains horizontal.



Prob. 5–3

***5–4.** The cable supports the loading shown. Determine the distance x and the tension in cable BC. Set $P = 100$ lb.

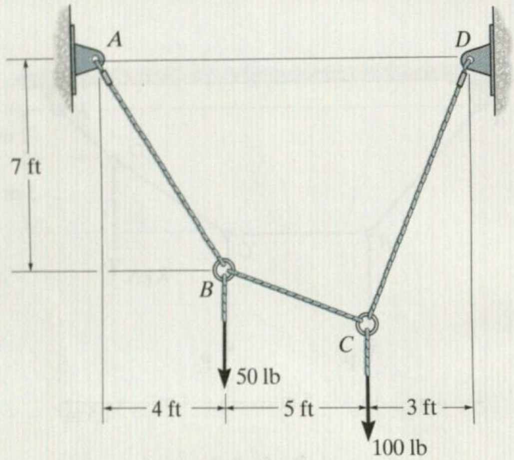
5–5. The cable supports the loading shown. Determine the magnitude of the horizontal force **P** so that $x = 6$ ft.



Probs. 5–4/5

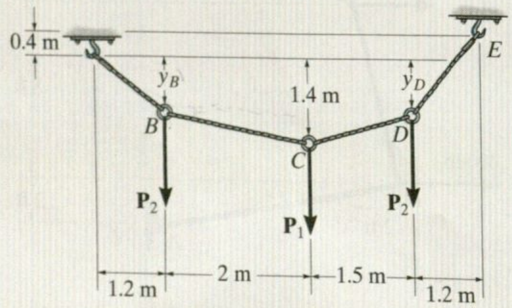
5

5–6. Determine the tension in each segment of the cable and the cable's total length.



Prob. 5–6

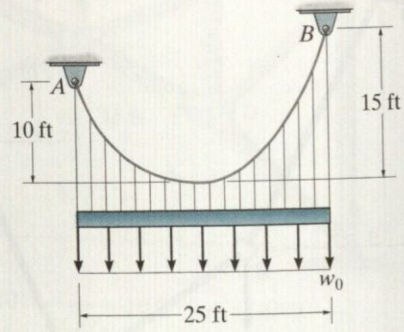
5–7. The cable supports the three loads shown. Determine the magnitude of $\mathbf{P}_1$ if $P_2 = 3$ kN and $y_B = 0.8$ m. Also find the sag y_D.



Prob. 5–7

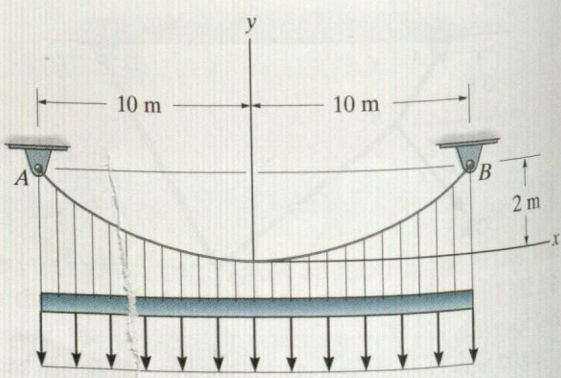
Sec. 5.3

***5–8.** The cable supports the uniform load of $w_0 = 600$ lb/ft. Determine the tension in the cable at each support A and B.



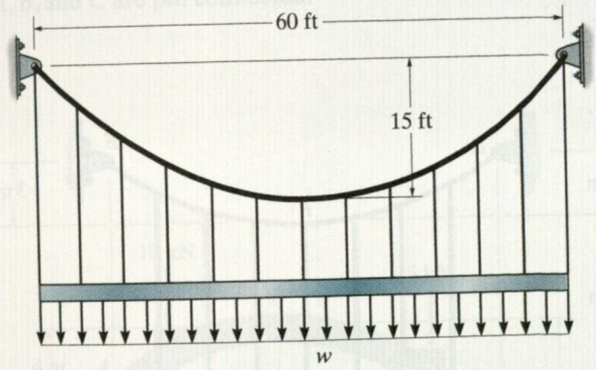
Prob. 5–8

5–9. Determine the maximum and minimum tension in the cable.



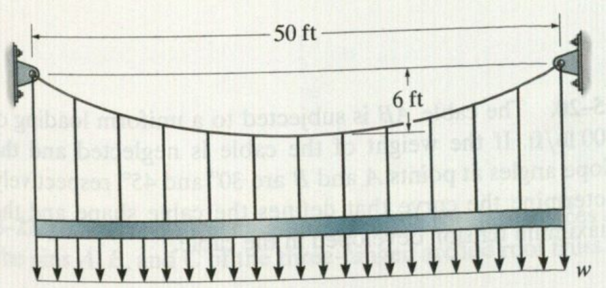
Prob. 5–9

5–10. The cable is subjected to a uniform loading of $w = 250\text{ lb/ft}$. Determine the maximum and minimum tension in the cable.



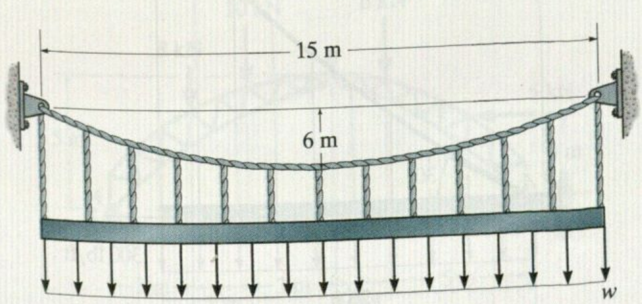
Prob. 5–10

5–11. The cable is subjected to a uniform loading of $w = 250\text{ lb/ft}$. Determine the maximum and minimum tension in the cable.



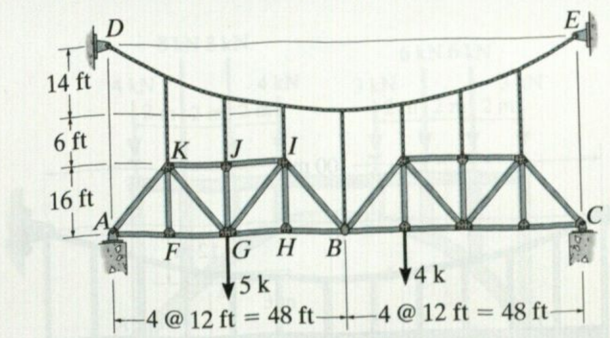
Prob. 5–11

***5–12.** The cable will break when the maximum tension reaches $T_{max} = 12\text{ kN}$. Determine the uniform distributed load w required to develop this maximum tension.



Prob. 5–12

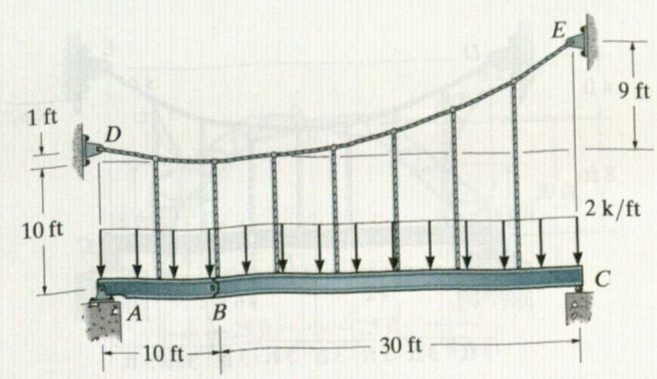
5–13. The trusses are pin connected and suspended from the parabolic cable. Determine the maximum force in the cable when the structure is subjected to the loading shown.



Prob. 5–13

5–14. Determine the maximum and minimum tension in the parabolic cable and the force in each of the hangers. The girder is subjected to the uniform load and is pin connected at B.

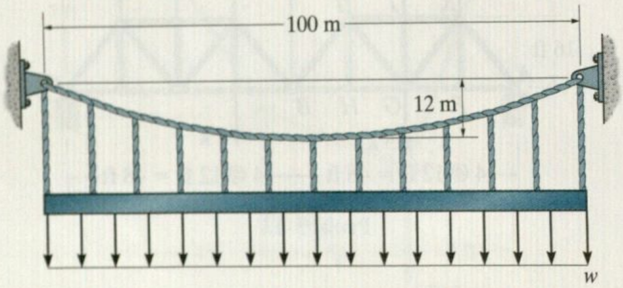
5–15. Draw the shear and moment diagrams for the pin connected girders AB and BC. The cable has a parabolic shape.



Probs. 5–14/15

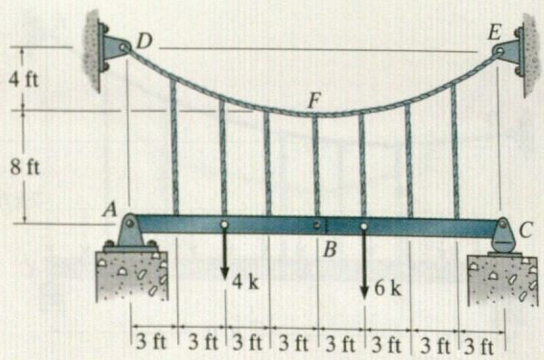
*5–16. The cable will break when the maximum tension reaches $T_{max} = 5000$ kN. Determine the maximum uniform distributed load w required to develop this maximum tension.

5–17. The cable is subjected to a uniform loading of $w = 60$ kN/m. Determine the maximum and minimum tension in cable.



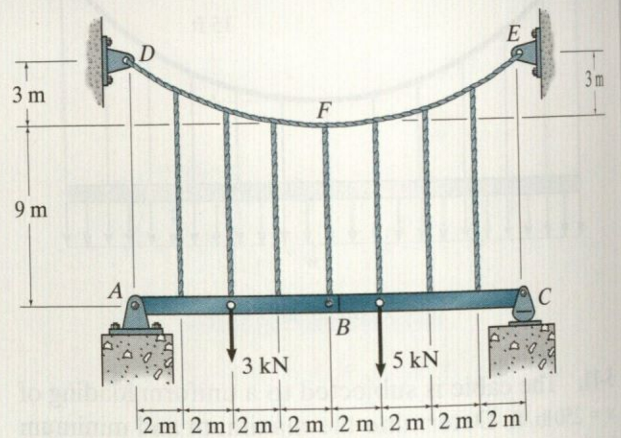
Probs. 5–16/17

5–18. The beams AB and BC are supported by the cable that has a parabolic shape. Determine the tension in the cable at points D, F, and E.



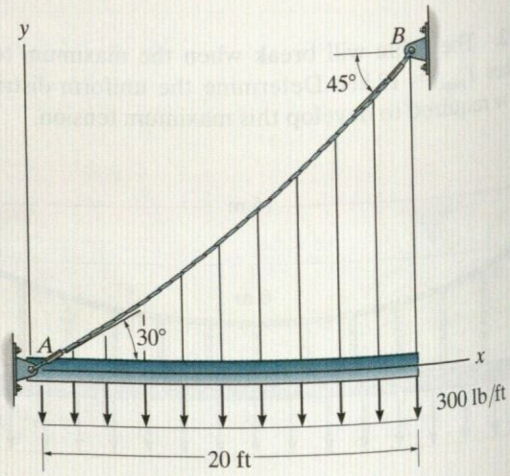
Prob. 5–18

5–19. The beams AB and BC are supported by the cable that has a parabolic shape. Determine the tension in the cable at points D, F, and E, and the force in each of the equally spaced hangers.



Prob. 5–19

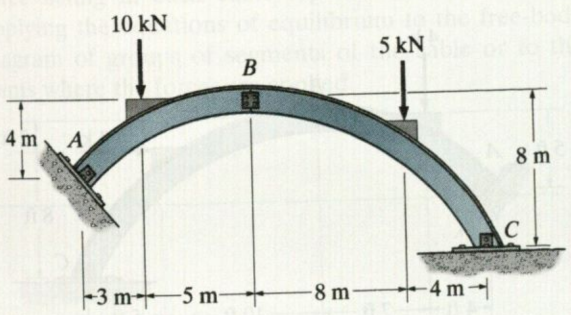
*5–20. The cable AB is subjected to a uniform loading of 300 lb/ft. If the weight of the cable is neglected and the slope angles at points A and B are 30° and 45°, respectively, determine the curve that defines the cable shape and the maximum tension developed in the cable.



Prob. 5–20

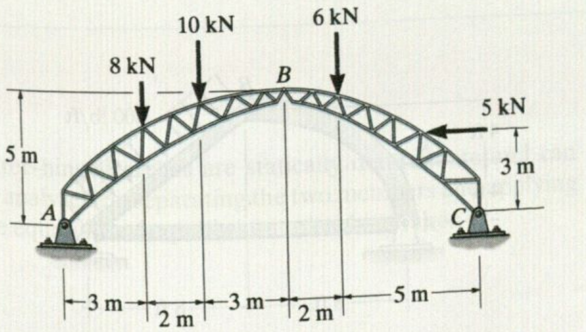
Sec. 5.4–5.5

5–21. Determine the horizontal and vertical components of reaction at *A*, *B*, and *C* of the three-hinged arch. Assume *A*, *B*, and *C* are pin connected.



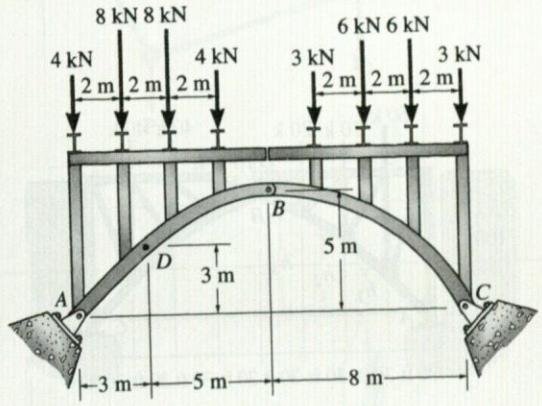
Prob. 5–21

5–22. Determine the magnitudes of the resultant forces at the pins *A*, *B*, and *C* of the three-hinged arched roof truss.



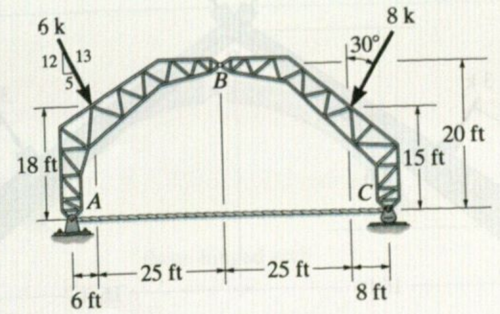
Prob. 5–22

5–23. The three-hinged spandrel arch is subjected to the loading shown. Determine the internal moment in the arch at point *D*.



Prob. 5–23

***5–24.** The tied three-hinged truss arch is subjected to the loading shown. Determine the components of reaction at *A* and *C*, and the tension in the tie rod.

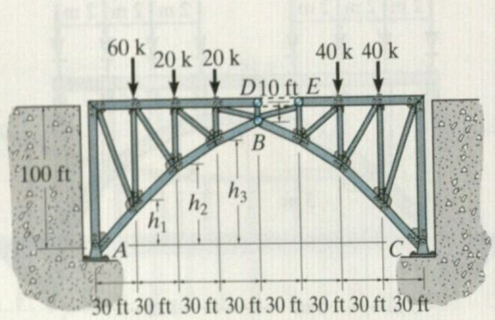


Prob. 5–24

5

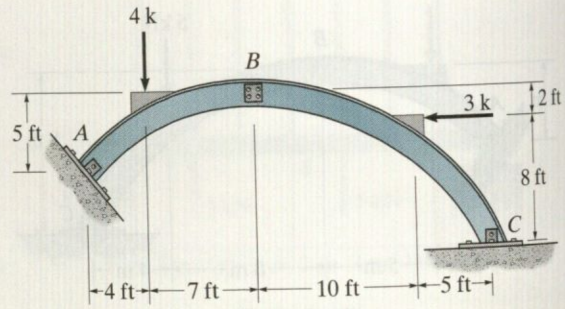
5–25. The bridge is constructed as a *three-hinged trussed arch*. Determine the horizontal and vertical components of reaction at the hinges (pins) at A, B, and C. The dashed member DE is intended to carry *no* force.

5–26. Determine the design heights h_1, h_2, and h_3 of the bottom cord of the truss so the three-hinged trussed arch responds as a funicular arch.



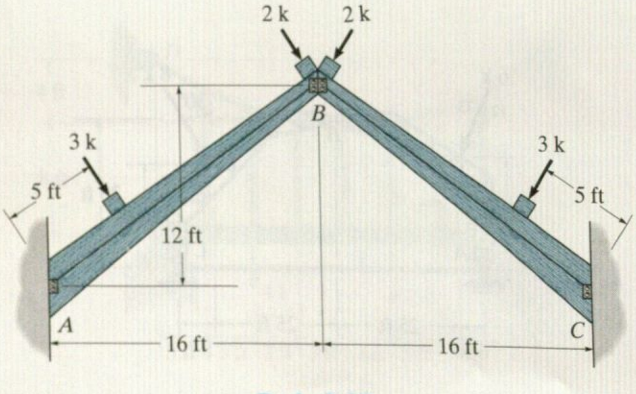
Probs. 5–25/26

***5–28.** Determine the horizontal and vertical components of reaction at A, B, and C of the three-hinged arch. Assume A, B, and C are pin connected.



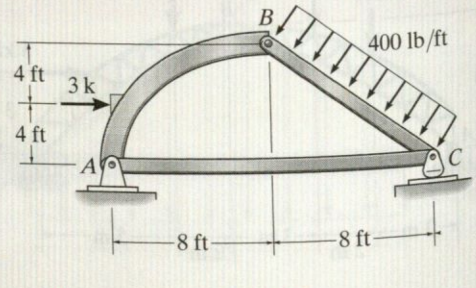
Prob. 5–28

5–27. The laminated-wood three-hinged arch is subjected to the loading shown. Determine the horizontal and vertical components of reactions at the pins A, B, and C, and draw the moment diagram for member AB.



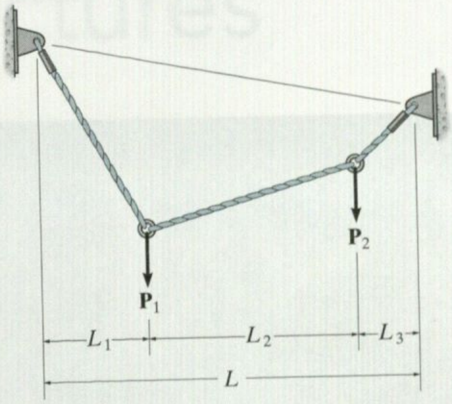
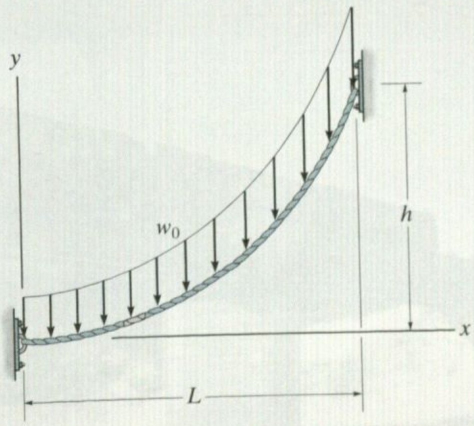
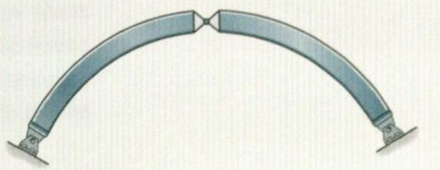
Prob. 5–27

5–29. The arch structure is subjected to the loading shown. Determine the horizontal and vertical components of reaction at A and C, and the force in member AC.



Prob. 5–29

CHAPTER REVIEW

Cables support their loads in tension if we consider them perfectly flexible.	
If the cable is subjected to concentrated loads then the force acting in each cable segment is determined by applying the equations of equilibrium to the free-body diagram of groups of segments of the cable or to the joints where the forces are applied.	
If the cable supports a uniform load over a projected horizontal distance, then the shape of the cable takes the form of a parabola.	
Arches are designed primarily to carry a compressive force. A parabolic shape is required to support a uniform loading distributed over its horizontal projection.	
Three-hinged arches are statically determinate and can be analyzed by separating the two members and applying the equations of equilibrium to each member.	 three-hinged arch