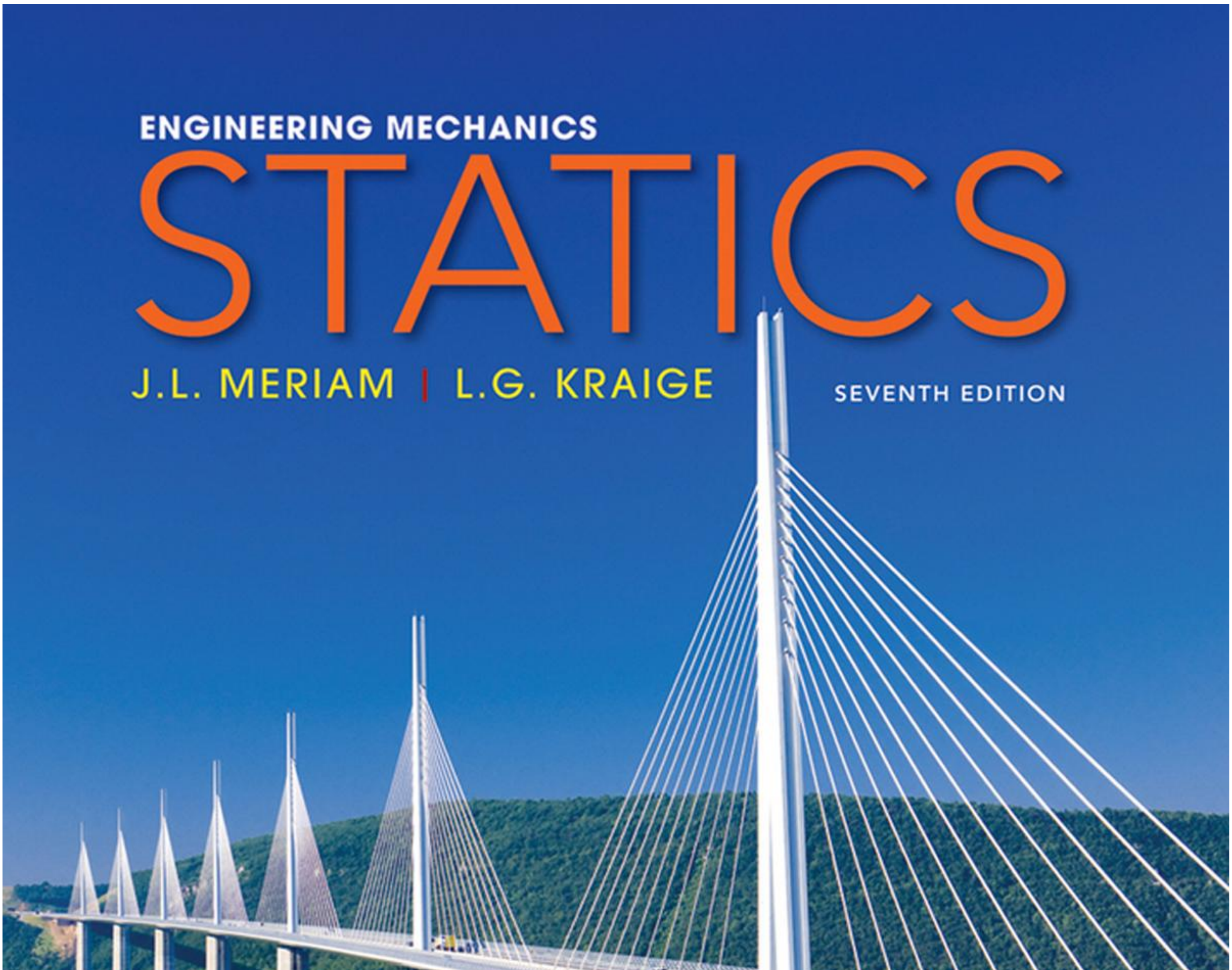
حل چند مثال از کابل ها با

SAP2000

تابش‌پور   دانشگاه صنعتی شریف


ENGINEERING MECHANICS
STATICS
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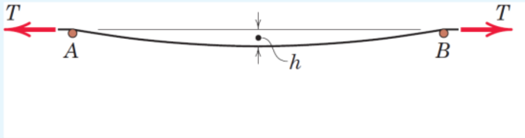
SEVENTH EDITION

SAMPLE PROBLEM 5/16

A 100-ft length of surveyor's tape weights 0.6 lb. When the tape is stretched between two points on the same level by a tension of 10 lb at each end, calculate the sag h in the middle.



Solution. The weight per unit length is $\mu = 0.6/100 = 0.006$ lb/ft. The total length is $2s = 100$ or $s = 50$ ft.

$$[T^2 = \mu^2 s^2 + T_0^2] \qquad 10^2 = (0.006)^2(50)^2 + T_0^2$$

1 $$T_0 = 9.995 \text{ lb}$$

$$[T = T_0 + \mu y] \qquad 10 = 9.995 + 0.006h$$

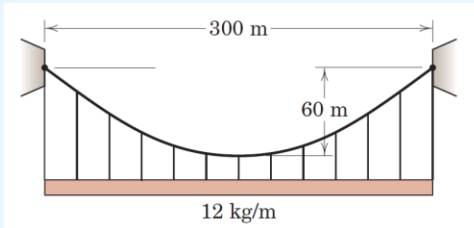
$$h = 0.750 \text{ ft} \quad \text{or} \quad 9.00 \text{ in.} \qquad \textit{Ans.}$$

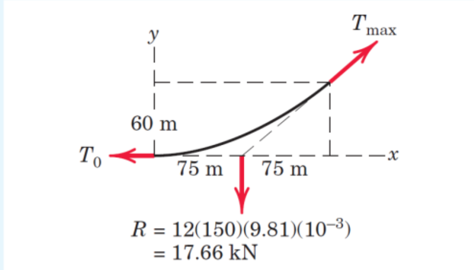
Helpful Hint

1 An extra significant figure is displayed here for clarity.

SAMPLE PROBLEM 5/17

The light cable supports a mass of 12 kg per meter of horizontal length and is suspended between the two points on the same level 300 m apart. If the sag is 60 m, find the tension at midlength, the maximum tension, and the total length of the cable.





Solution. With a uniform horizontal distribution of load, the solution of part (*b*) of Art. 5/8 applies, and we have a parabolic shape for the cable. For $h = 60$ m, $L = 300$ m, and $w = 12(9.81)(10^{-3})$ kN/m the relation following Eq. 5/14 with $l_A = L/2$ gives for the midlength tension

$$\left[T_0 = \frac{wL^2}{8h}\right] \qquad T_0 = \frac{0.1177(300)^2}{8(60)} = 22.1 \text{ kN} \qquad \textit{Ans.}$$

The maximum tension occurs at the supports and is given by Eq. 5/15*b*. Thus,

1 $$\left[T_{max} = \frac{wL}{2}\sqrt{1 + \left(\frac{L}{4h}\right)^2}\right]$$

$$T_{max} = \frac{12(9.81)(10^{-3})(300)}{2}\sqrt{1 + \left(\frac{300}{4(60)}\right)^2} = 28.3 \text{ kN} \qquad \textit{Ans.}$$

The sag-to-span ratio is $60/300 = 1/5 < 1/4$. Therefore, the series expression developed in Eq. 5/16*a* is convergent, and we may write for the total length

$$S = 300\left[1 + \frac{8}{3}\left(\frac{1}{5}\right)^2 - \frac{32}{5}\left(\frac{1}{5}\right)^4 + \cdots\right]$$

$$= 300[1 + 0.1067 - 0.01024 + \cdots]$$

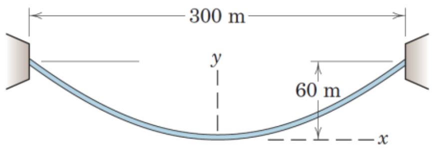
$$= 329 \text{ m} \qquad \textit{Ans.}$$

Helpful Hint

1 *Suggestion:* Check the value of T_{max} directly from the free-body diagram of the right-hand half of the cable, from which a force polygon may be drawn.

SAMPLE PROBLEM 5/18

Replace the cable of Sample Problem 5/17, which is loaded uniformly along the horizontal, by a cable which has a mass of 12 kg per meter of its own length and supports its own weight only. The cable is suspended between two points on the same level 300 m apart and has a sag of 60 m. Find the tension at midlength, the maximum tension, and the total length of the cable.

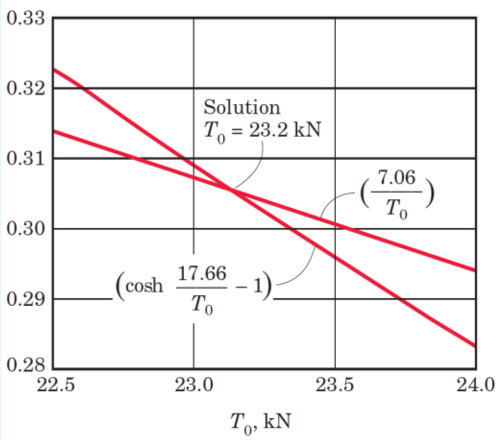


Solution. With a load distributed uniformly along the length of the cable, the solution of part (*c*) of Art. 5/8 applies, and we have a catenary shape of the cable. Equations 5/20 and 5/21 for the cable length and tension both involve the minimum tension T_0 at midlength, which must be found from Eq. 5/19. Thus, for $x = 150$ m, $y = 60$ m, and $\mu = 12(9.81)(10^{-3}) = 0.1177$ kN/m, we have

$$60 = \frac{T_0}{0.1177}\left[\cosh\frac{(0.1177)(150)}{T_0} - 1\right]$$

or
$$\frac{7.06}{T_0} = \cosh\frac{17.66}{T_0} - 1$$

This equation can be solved graphically. We compute the expression on each side of the equals sign and plot it as a function of T_0. The intersection of the two curves establishes the equality and determines the correct value of T_0. This plot is shown in the figure accompanying this problem and yields the solution



$$T_0 = 23.2 \text{ kN}$$

Alternatively, we may write the equation as

$$f(T_0) = \cosh\frac{17.66}{T_0} - \frac{7.06}{T_0} - 1 = 0$$

and set up a computer program to calculate the value(s) of T_0 which renders $f(T_0) = 0$. See Art. C/11 of Appendix C for an explanation of one applicable numerical method.

The maximum tension occurs for maximum y and from Eq. 5/22 is

$$T_{max} = 23.2 + (0.1177)(60) = 30.2 \text{ kN} \qquad \textit{Ans.}$$

1 From Eq. 5/20 the total length of the cable becomes

$$2s = 2\,\frac{23.2}{0.1177}\sinh\frac{(0.1177)(150)}{23.2} = 330 \text{ m} \qquad \textit{Ans.}$$

Helpful Hint

1 Note that the solution of Sample Problem 5/17 for the parabolic cable gives a very close approximation to the values for the catenary even though we have a fairly large sag. The approximation is even better for smaller sag-to-span ratios.