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Procedures and Strategies for Solving Problems Involving Catenary Cables

To solve catenary-cable problems, you must determine the "parameter of the catenary," c.

1. If the coordinates x and y of a point on the cable are known, determine c from

\[ y = c \cosh \left( \frac{x}{c} \right) \]  \hspace{1cm} (1)

2. If the x coordinate of a point on the cable and the corresponding cable length s are known, determine c from

\[ s = \sinh \left( \frac{x}{c} \right) \]  \hspace{1cm} (2)

3. If the y coordinate of a point on the cable and the length s are known, determine c from

\[ y^2 - s^2 = c^2 \]  \hspace{1cm} (3)

4. If the tension T is known at a point on the cable, determine the y coordinate of the point from

\[ T = wy \]  \hspace{1cm} (4)

Then if either x or s is known, then use either Eq. 1 or 3 to solve for c.
5. If the slope of the cable is known at a point on the cable with coordinate x, then differentiate Eq. 1 to obtain an equation that can be solved for c.

Frequently, solving catenary-cable problem requires finding roots of nonlinear algebraic equations. You can usually handle these problems by using the solver on your calculator, but some equations have multiple roots, and you must determine which of the roots are physically realistic.
6.7 Cables: Catenaries Problem Statement for Example 1
1. An electric power line of length 140 m and mass per unit length of 3 kg/m is to be suspended between two towers 120 m apart and of the same height. Determine the sag and maximum tension in the power line.
6.7 Cables: Catenaries Problem Statement for Example 2

2. A cable is supported at two points 400 ft apart and at the same elevation. If the sag is 40 ft and the weight per unit length of the cable is 4 lb/ft, determine the length of the cable and the tension at the low point, C.
6.7 Cables: Catenaries Problem Statement for Example 3

3. A 20-m chain is suspended between two points at the same elevation and with a sag of 6 m as shown. If the total mass of the chain 45 kg, determine the distance between the supports. Also determine the maximum tension.
6.7 Cables: Catenaries Problem Statement for Example 4

4. A certain cable will break if the maximum tension exceeds 500 N. If the cable is 50-m long and has a mass of 50 kg, determine the greatest span possible. Also determine the sag.

A  B

Supports A and B are at the same elevation.
6.7 Cables: Catenaries Problem Statement for Example 5

5. The cable is attached to a fixed support at A and a moveable support at B. If the cable is 80-ft long, weighs 0.3 lb/ft, and spans 50 ft, determine the force F holding the moveable support in place. Also determine the sag.
6.7 Cables: Catenaries Problem Statement for Example 6

6. The cable is attached to a fixed support at A and a moveable support B. If the cable is 40-m long and has a mass of 0.4 kg/m, determine the span and sag.
6.7 Cables: Catenaries Problem Statement for Example 7

7. A cable goes over a frictionless pulley at B and supports a block of mass m. The other end of the cable is pulled by a horizontal force P. If the cable has a mass per length of 0.3 kg/m, determine values of P and m that will maintain the cable in the position shown.
6.7 Cables: Catenaries Problem Statement for Example 8

8. A chain makes angles of 30° and 60° at its supports as shown. Determine the location of the low point C of the chain relative to A. Also determine the tension at support A, if the cable has a mass per length of 0.6 kg/m.

Supports A and B are at different elevation.
6.7 Cables: Catenaries Problem Statement for Example 9

9. A wire weighing 0.2 lb/ft is attached to a moveable support at A and makes an angle of 55° at a fixed support at B. Supports A and B are at different elevations. Determine the location of the low point C of the wire relative to support B. Also, determine the tension in the wire at C.
10. Determine the location of the low point C relative to the support at A. Also determine the tension at C, if the mass of the cable per unit length is 1 kg/m.