Golden Gate Tower Problem

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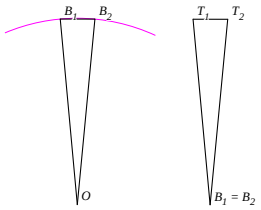
1 The Problem

The Golden Gate Bridge connects San Francisco, California to Marin County to the north. The main span of the bridge is supported by a pair of towers that rise from sea level.

Since the earth's surface is curved and the tower bases are about a mile apart and both towers point directly away from the center of the earth, their bases must be closer together than the tops of the towers. The question is, "How much closer?"

Here are all the numbers you need: The radius of the earth is 3959 miles; the bases of the towers are 4200 feet apart; the heights of the towers from base to top is 746 feet.



On the left in Figure 1, the point O is the center of the earth and the purple arc above represents the surface of the earth, and B_1 and B_2 are the bases of the two towers on the surface of the water. We have:

$$\begin{aligned} OB_1 &= OB_2 = 3959 \text{ miles.} \\ B_1B_2 &= 4200 \text{ feet.} \end{aligned}$$

Now forget that the planet exists and move the two bases together keeping the angle between them fixed, and you'll obtain the right side of the figure above. T_1 and T_2 represent the tops of the towers. We want to find x, the distance between T_1 and T_2. We have:

$$\begin{aligned} B_1T_1 &= B_2T_2 = 746 \text{ feet.} \\ T_1T_2 &= x \text{ feet.} \end{aligned}$$

Since the two triangles are obviously similar we have:

$$\frac{4200}{3959 \cdot 5280} = \frac{x}{746}.$$

This yields $x = .1499$ feet $= 1.799$ inches.