Problem 24: PM - Civil Eng.

A back tangent with a +7% grade meets a forward tangent with a −5% grade on a vertical alignment. A 350 m (10-station) horizontal length of vertical curve is placed such that the point of vertical curvature (PVC) is at sta 10+35 at an elevation of 60.0 m.
The tangent elevation at the point of vertical intersection (PVI) is most nearly

(A) 66 m
(B) 68 m
(C) 70 m
(D) 72 m

Solution:

The PVI is located at x = L/2 = (350 m)/2 = 175 m from the PVC. From the tangent elevation equation, the tangent elevation is found to be

$$
\begin{aligned}
y_{\text{PVC}} + g_1 x &= 60.0\ m + (+7\%)\left(\frac{1}{100\%}\right)(175\ m) \\
&= 72.2\ m \quad (72\ m)
\end{aligned}
$$

The answer is D.

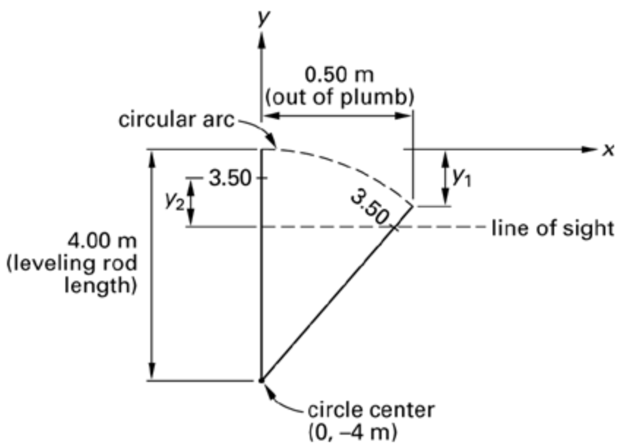
Problem 25: PM - Civil Eng.

A reading of 3.50 m is taken on a 4 m leveling rod that is 0.50 m out of plumb at the top of the rod. The correct reading, when the rod is truly vertical, is most nearly

(A) 3.06 m
(B) 3.47 m
(C) 3.53 m
(D) 3.94 m

Solution:

The 4 m long rod can be described as extending from the center of a 4 m radius circle. The end of the rod is at the top of the circle when it is truly vertical and makes a circular arc when it goes out of plumb.



With the reference taken at the top of the circle, the center is at coordinates $h = x = 0$ ft and $k = y = -4$ m. The equation of a circle with the center at (h, k) and a radius, r, is

$$(x-h)^2 + (y-k)^2 = r^2$$
$$(x-0\ m)^2 + (y+4\ m)^2 = (4\ m)^2$$

Removing units for simplicity (but remembering that all distances are in meters) and simplifying the equation gives

$$y^2 + 8y + x^2 = 0$$

From this, the change in vertical distance at the top end of the rod when it goes 0.50 m out of plumb can be solved by letting $x = 0.50$ and solving for y.

$$\begin{aligned} y^2 + 8y + x^2 &= 0 \\ y^2 + 8y + (0.50)^2 &= 0 \\ y^2 + 8y + 0.25 &= 0 \\ y &= -0.0314 \quad \text{[the nontrivial solution]} \end{aligned}$$

Therefore, the change in vertical distance of the leveling rod end is $y_1 = -y = 0.0314$ m.
A ratio of the smaller circular arc with a radius of 3.50 m to the larger circular arc with a radius of 4.00 m can be used to find y_2.

$$\begin{aligned} \frac{y_2}{3.50\ m} &= \frac{y_1}{4.00\ m} \\ y_2 &= (3.50\ m)\left(\frac{y_1}{4.00\ m}\right) = (3.50\ m)\left(\frac{0.0314\ m}{4.00\ m}\right) \\ &= 0.0275\ m \end{aligned}$$

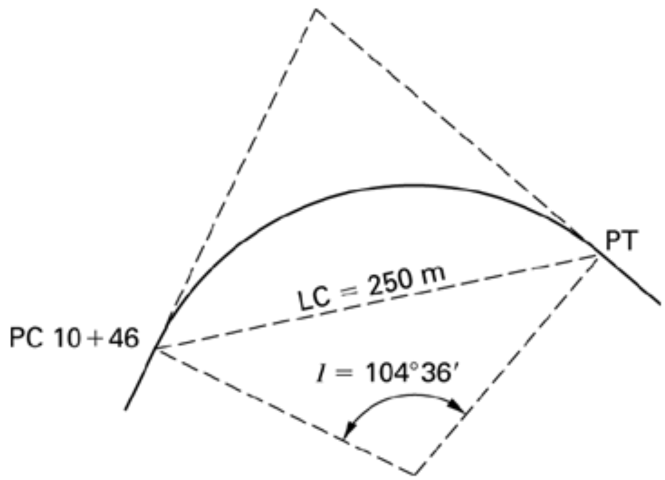
Since the out-of-plumb reading was 3.50 m, the correct reading with the rod truly vertical is

$$3.50\ m - y_2 = 3.50\ m - 0.0275\ m = 3.47\ m$$

The answer is B.

Problem 26: PM - Civil Eng.

A horizontal curve is laid out with the point of curve (PC) station and the length of long chord (LC) as shown.

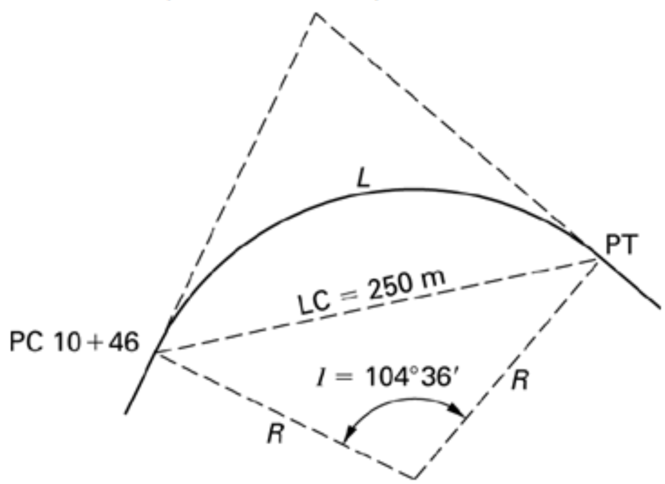


The radius of the curve is most nearly

(A) 158 m
(B) 160 m
(C) 316 m
(D) 320 m

Solution:

A sketch of the required distances is helpful.



The intersection of angle, I, should be converted into a decimal angle to give

$$I = 104° + (36')\left(\frac{1°}{60'}\right) = 104.6°$$

The radius of the curve is

$$R = \frac{\text{LC}}{2\sin\left(\frac{I}{2}\right)} = \frac{250\ m}{2\sin\left(\frac{104.6°}{2}\right)} = 158.0\ m$$

The answer is A.