5.9 The loop shown in Fig. P5.9 consists of radial lines and segments of circles whose centers are at point P. Determine the magnetic field $\mathbf{H}$ at P in terms of a, b, θ, and I.

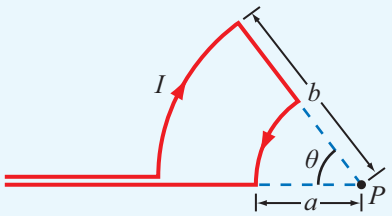

Figure P5.9 Configuration of Problem 5.9.

Solution: From the solution to Example 5-3, if we denote the z-axis as passing out of the page through point P, the magnetic field pointing out of the page at P due to the current flowing in the outer arc is $\mathbf{H}_{\text{outer}} = -\hat{\mathbf{z}}I\theta/4\pi b$ and the field pointing out of the page at P due to the current flowing in the inner arc is $\mathbf{H}_{\text{inner}} = \hat{\mathbf{z}}I\theta/4\pi a$. The other wire segments do not contribute to the magnetic field at P. Therefore, the total field flowing directly out of the page at P is

$$\mathbf{H} = \mathbf{H}_{\text{outer}} + \mathbf{H}_{\text{inner}} = \hat{\mathbf{z}}\frac{I\theta}{4\pi}\left(\frac{1}{a} - \frac{1}{b}\right) = \hat{\mathbf{z}}\frac{I\theta\,(b-a)}{4\pi ab}.$$