[Cheng P.6-11] A long wire carrying a current I folds back with a semicircular bend of radius b as in Fig. 6-38. Determine the magnetic flux density at the center point P of the bend.
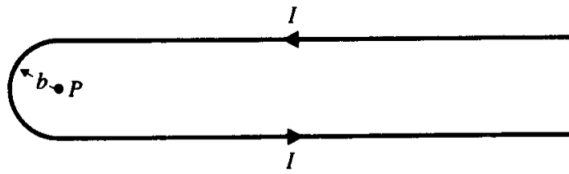

FIGURE 6–38
A very long wire with a semicircular bend (Problem P.6–11).

Solution: This problem is the superposition of two problems:

$$\mathbf{B} = \mathbf{B}_1 + \mathbf{B}_2,$$

where

1. $\mathbf{B}_1$ is the magnetic flux density at P due to two semi-infinite wires carrying equal and opposite currents.

   Assuming $\mathbf{a}_z$ points out of the page:

   $$\mathbf{B}_1 = \mathbf{a}_z \frac{\mu_0 I}{2\pi b}.$$

2. $\mathbf{B}_2$ is the magnetic flux density at P due to a half circle. Taking one half of the result in Eq. (6-38) for $z = 0$

   $$\mathbf{B}_2 = \mathbf{a}_z \frac{\mu_0 I}{4b}$$

Therefore,

$$\mathbf{B} = \mathbf{a}_z \frac{\mu_0 I}{2b} \left(\frac{1}{\pi} + \frac{1}{2} \right).$$

Answer:

$$\mathbf{B} = \mathbf{a}_z \frac{\mu_0 I}{2b} \left(\frac{1}{\pi} + \frac{1}{2} \right)$$