Problem 5.11 An infinitely long wire carrying a 25-A current in the positive x-direction is placed along the x-axis in the vicinity of a 20-turn circular loop located in the x–y plane (Fig. P5.11). If the magnetic field at the center of the loop is zero, what is the direction and magnitude of the current flowing in the loop?

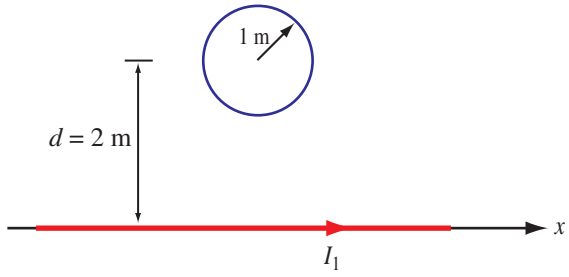

Figure P5.11: Circular loop next to a linear current (Problem 5.11).

Solution: From Eq. (5.30), the magnetic flux density at the center of the loop due to

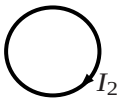

Figure P5.11: (b) Direction of I_2.

the wire is

$$\mathbf{B}_1 = \hat{\mathbf{z}}\,\frac{\mu_0}{2\pi d}\,I_1$$

where $\hat{\mathbf{z}}$ is out of the page. Since the net field is zero at the center of the loop, I_2 must be clockwise, as seen from above, in order to oppose I_1. The field due to I_2 is, from Eq. (5.35),

$$\mathbf{B} = \mu_0\mathbf{H} = -\hat{\mathbf{z}}\,\frac{\mu_0 N I_2}{2a}\,.$$

Equating the magnitudes of the two fields, we obtain the result

$$\frac{NI_2}{2a} = \frac{I_1}{2\pi d}\,,$$

or

$$I_2 = \frac{2aI_1}{2\pi N d} = \frac{1\times 25}{\pi\times 20\times 2} = 0.2\text{ A}.$$