33.18. Model: The radius of the earth is much larger than the size of the current loop.

Solve: **(a)** From Equation 33.9, the magnetic field strength at the surface of the earth at the earth's north pole is

$$B = \frac{\mu_0}{2\pi}\frac{\mu}{z^3} = \frac{\left(2\times10^{-7}\ \text{T m/A}\right)\left(8.0\times10^{22}\ \text{A m}^2\right)}{\left(6.38\times10^{6}\ \text{m}\right)^3} = 6.2\times10^{-5}\ \text{T}$$

This value is close to the value of 5×10^{-5} T given in Table 33.1.

(b) The current required to produce a dipole moment like that on the earth is

$$\mu = AI = \left(\pi R_{\text{earth}}^2\right)I \Rightarrow 8.0 \times 10^{22}\ \text{A m}^2 = \pi(6.38 \times 10^6\ \text{m})^2 I \Rightarrow I = 6.3 \times 10^8\ \text{A}$$

Assess: This is an extremely large current to run through a wire around the equator.

33.24. Model: Assume that the solenoid is an ideal solenoid.

Solve: We can use Equation 33.16 to find the current that will generate a 3.0 mT field inside the solenoid:

$$B_{\text{solenoid}} = \frac{\mu_0 NI}{l} \Rightarrow I = \frac{B_{\text{solenoid}} l}{\mu_0 N}$$

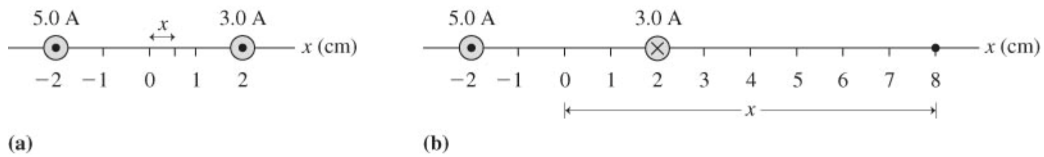
Using $l = 0.15$ m and $N = 0.15 \text{ m}/0.0010 \text{ m} = 150$,

$$I = \frac{(3.0 \times 10^{-3} \text{ T})(0.15 \text{ m})}{(4\pi)(10^{-7} \text{ T m/A})(150)} = 2.4 \text{ A}$$

Assess: This is a reasonable current to pass through a good conducting wire of diameter 1 mm.

33.42. Model: The magnetic field is that of two long wires that carry current.

Visualize:



Solve: **(a)** For $x > +2$ cm and for $x < -2$ cm, the magnetic fields due to the currents in the two wires add. The point where the two magnetic fields cancel lies on the x-axis in between the two wires. Let that point be a distance x away from the origin. Because the magnetic field of a long wire is $B = \mu_0 I/2\pi r$, we have

$$\frac{\mu_0}{2\pi}\frac{(5.0\text{ A})}{(0.020\text{ m}+x)} = \frac{\mu_0}{2\pi}\frac{(3.0\text{ A})}{(0.020\text{ m}-x)} \Rightarrow 5(0.020\text{ m}-x) = 3(0.020\text{ m}+x) \Rightarrow x = 0.0050\text{ m} = 0.50\text{ cm}$$

(b) The magnetic fields due to the currents in the two wires add in the region -2.0 cm $< x <$ 2.0 cm. For $x <$ -2.0 cm, the magnetic fields subtract, but the field due to the 5.0 A current is always larger than the field due to the 3.0 A current. However, for $x >$ 2.0 m, the two fields will cancel at a point on the x-axis. Let that point be a distance x away from the origin, so

$$\frac{\mu_0}{2\pi}\frac{5.0\text{ A}}{x+0.020\text{ m}} = \frac{\mu_0}{2\pi}\frac{3.0\text{ A}}{x-0.020\text{ m}} \Rightarrow 5(x-0.020\text{ m}) = 3(x+0.020\text{ m}) \Rightarrow x = 8.0\text{ cm}$$

33.48. Model: Assume that the wire is infinitely long.

Visualize: Please refer to Figure P33.48. The wire, looped as it is, consists of a circular part and a linear part.

Solve: Using Equation 33.7 and Example 33.3, the magnetic field at P is

$$B_P = B_{\text{loop center}} + B_{\text{wire}} = \frac{\mu_0 I}{2R} + \frac{\mu_0 I}{2\pi R}$$

$$= \frac{4\pi(10^{-7}\text{ T m/A})(5.0\text{ A})}{2(0.010\text{ m})} + \frac{4\pi(10^{-7}\text{ T m/A})(5.0\text{ A})}{2\pi(0.010\text{ m})} = 4.1\times10^{-4}\text{ T}$$