1. (a) The magnitude of the magnetic field due to the current in the wire, at a point a distance r from the wire, is given by

$$B = \frac{\mu_0 i}{2\pi r}.$$

With r = 20 ft = 6.10 m, we have

$$B = \frac{\left(4\pi \times 10^{-7}\,\text{T}\cdot\text{m/A}\right)\left(100\,\text{A}\right)}{2\pi\left(6.10\,\text{m}\right)} = 3.3\times 10^{-6}\,\text{T} = 3.3\,\mu\text{T}.$$

(b) This is about one-sixth the magnitude of the Earth's field. It will affect the compass reading.

7. (a) Recalling the *straight sections* discussion in Sample Problem — "Magnetic field at the center of a circular arc of current," we see that the current in the straight segments collinear with P do not contribute to the field at that point. Using Eq. 29-9 (with $\phi = \theta$) and the right-hand rule, we find that the current in the semicircular arc of radius b contributes $\mu_0 i\theta/4\pi b$ (out of the page) to the field at P. Also, the current in the large radius arc contributes $\mu_0 i\theta/4\pi a$ (into the page) to the field there. Thus, the net field at P is

$$B = \frac{\mu_0 i\theta}{4}\left(\frac{1}{b}-\frac{1}{a}\right) = \frac{(4\pi\times 10^{-7}\,\text{T}\cdot\text{m/A})(0.411\text{A})(74°\cdot\pi/180°)}{4\pi}\left(\frac{1}{0.107\text{m}}-\frac{1}{0.135\text{m}}\right)$$
$$=1.02\times 10^{-7}\,\text{T}.$$

(b) The direction is out of the page.

11. (a) $B_{P_1} = \mu_0 i_1/2\pi r_1$ where i_1 = 6.5 A and $r_1 = d_1 + d_2$ = 0.75 cm + 1.5 cm = 2.25 cm, and $B_{P_2} = \mu_0 i_2/2\pi r_2$ where $r_2 = d_2$ = 1.5 cm. From $B_{P1} = B_{P2}$ we get

$$i_2 = i_1\left(\frac{r_2}{r_1}\right) = \left(6.5\,\text{A}\right)\left(\frac{1.5\,\text{cm}}{2.25\,\text{cm}}\right) = 4.3\,\text{A}.$$

(b) Using the right-hand rule, we see that the current i_2 carried by wire 2 must be out of the page.

12. (a) Since they carry current in the same direction, then (by the right-hand rule) the only region in which their fields might cancel is between them. Thus, if the point at which we are evaluating their field is r away from the wire carrying current i and is $d - r$ away from the wire carrying current $3.00i$, then the canceling of their fields leads to

$$\frac{\mu_0 i}{2\pi r} = \frac{\mu_0(3i)}{2\pi(d-r)} \quad\Rightarrow\quad r = \frac{d}{4} = \frac{16.0\text{ cm}}{4} = 4.0\text{ cm}.$$

(b) Doubling the currents does not change the location where the magnetic field is zero.

15. (a) As discussed in Sample Problem — "Magnetic field at the center of a circular arc of current," the radial segments do not contribute to $\vec{B}_P$ and the arc segments contribute according to Eq. 29-9 (with angle in radians). If $\hat{\mathrm{k}}$ designates the direction "out of the page" then

$$\vec{B} = \frac{\mu_0 (0.40\,\mathrm{A})(\pi\,\mathrm{rad})}{4\pi(0.050\,\mathrm{m})}\hat{\mathrm{k}} - \frac{\mu_0 (0.80\,\mathrm{A})(2\pi/3\,\mathrm{rad})}{4\pi(0.040\,\mathrm{m})}\hat{\mathrm{k}} = -(1.7\times10^{-6}\ \mathrm{T})\hat{\mathrm{k}}$$

or $|\vec{B}| = 1.7\times10^{-6}\,\mathrm{T}$.

(b) The direction is $-\hat{\mathrm{k}}$, or into the page.

(c) If the direction of i_1 is reversed, we then have

$$\vec{B} = -\frac{\mu_0 (0.40\,\mathrm{A})(\pi\,\mathrm{rad})}{4\pi(0.050\,\mathrm{m})}\hat{\mathrm{k}} - \frac{\mu_0 (0.80\,\mathrm{A})(2\pi/3\,\mathrm{rad})}{4\pi(0.040\,\mathrm{m})}\hat{\mathrm{k}} = -(6.7\times10^{-6}\ \mathrm{T})\hat{\mathrm{k}}$$

or $|\vec{B}| = 6.7\times10^{-6}\,\mathrm{T}$.

(d) The direction is $-\hat{\mathrm{k}}$, or into the page.

16. Using the law of cosines and the requirement that B = 100 nT, we have

$$\theta = \cos^{-1}\left(\frac{B_1^2 + B_2^2 - B^2}{-2B_1B_2}\right) = 144°\,,$$

where Eq. 29-10 has been used to determine B_1 (168 nT) and B_2 (151 nT).

27. We use Eq. 29-4 to relate the magnitudes of the magnetic fields B_1 and B_2 to the currents (i_1 and i_2, respectively) in the two long wires. The angle of their net field is

$$\theta = \tan^{-1}(B_2/B_1) = \tan^{-1}(i_2/i_1) = 53.13°.$$

To accomplish the net field rotation described in the problem, we must achieve a final angle $\theta' = 53.13° - 20° = 33.13°$. Thus, the final value for the current i_1 must be $i_2/\tan\theta'$ = 61.3 mA.