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 \( r = 20 \text{ ft} = 6.10 \text{ m} \), we have

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

(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

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

\[
= 1.02 \times 10^{-7} \text{ T}.
\]

(b) The direction is out of the page.

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

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

(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

\[
\frac{\mu_0 i}{2\pi r} = \frac{\mu_0 (3i)}{2\pi(d-r)} \quad \Rightarrow \quad r = \frac{d}{4} = 16.0 \text{ cm} = 4.0 \text{ cm}.
\]
(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 $\vec{B}_r$ and the arc segments contribute according to Eq. 29-9 (with angle in radians). If $\hat{k}$ designates the direction “out of the page” then

$$\vec{B} = \frac{\mu_0 (0.40 \text{ A})(\pi \text{ rad})}{4\pi (0.050 \text{ m})} \hat{k} - \frac{\mu_0 (0.80 \text{ A})(2\pi/3 \text{ rad})}{4\pi (0.040 \text{ m})} \hat{k} = -(1.7 \times 10^{-6} \text{ T}) \hat{k}$$

or $|\vec{B}| = 1.7 \times 10^{-6} \text{ T}$.

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

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

$$\vec{B} = -\frac{\mu_0 (0.40 \text{ A})(\pi \text{ rad})}{4\pi (0.050 \text{ m})} \hat{k} - \frac{\mu_0 (0.80 \text{ A})(2\pi/3 \text{ rad})}{4\pi (0.040 \text{ m})} \hat{k} = -(6.7 \times 10^{-6} \text{ T}) \hat{k}$$

or $|\vec{B}| = 6.7 \times 10^{-6} \text{ T}$.

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

16. Using the law of cosines and the requirement that $B = 100 \text{ nT}$, we have

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

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

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