Solutions Problem Set # 1

Ch. 33 Conceptual Questions

33.1. **(a)** The sphere is not effected by the magnet. Glass is not magnetic.
(b) There is no magnetic force between the glass sphere and magnet since magnetic forces act on moving charges and some metals. There is, however, a weak attraction due to a polarization of the charges if the magnet is metal.

33.2. It is attracted. Magnetic materials are attracted to both poles of a magnet. This is analogous to how neutral objects are attracted to both positively and negatively charged rods by the polarization force.

33.4. Because the north poles of the compass magnets point counterclockwise, the magnetic force is counterclockwise. When you point fingers of your right hand counterclockwise, the thumb points up. Thus, the current in the wire is out of the page.

33.3. Yes, if both cylinders are magnets they will repel if one of them is turned 180°. If only one cylinder is a magnet, then they will still attract after one of them is turned around.

Ch. 33 Problems

33.6. Model: The magnetic field is that of a moving charged particle.
Visualize: Please refer to Figure EX33.6.
Solve: The Biot-Savart law is

$$B = \frac{\mu_0}{4\pi}\frac{qv\sin\theta}{r^2} = \frac{(10^{-7}\ \text{T m/A})(1.60\times10^{-19}\ \text{C})(2.0\times10^{7}\ \text{m/s})\sin135^\circ}{(2.0\times10^{-2}\ \text{m})^2+(2.0\times10^{-2}\ \text{m})^2} = 2.83\times10^{-16}\ \text{T}$$

The right-hand rule for the *positive charge* indicates the field points out of the page. Thus, $\vec{B} = 2.83\times10^{-16}\hat{k}$ T.

33.12. Model: The magnetic field is the superposition of the magnetic fields of three wire segments.
Visualize: Please refer to Figure EX33.12.
Solve: The magnetic field of the horizontal wire, with current I, encircles the wire. Because the dot is on the axis of the wire, the input current creates no magnetic field at this point. The current divides at the junction, with $I/2$ traveling upward and $I/2$ traveling downward. The right-hand rule tells us that the upward current creates a field at the dot that is into the page; the downward current creates a field that is out of the page. Although we could calculate the strength of each field, the symmetry of the situation (the dot is the same distance and direction from the base of each wire) tells us that the fields of the upward and downward current must have the same strength. Since they are in opposite directions, their sum is $\vec{0}$. Altogether, then, the field at the dot is $\vec{B} = \vec{0}$ T.

33.14. Model: Assume the wires are infinitely long.
Visualize: Please refer to Figure EX33.14.
Solve: The magnetic field strength at point a is

$$\vec{B}_{\text{at a}} = \vec{B}_{\text{top}} + \vec{B}_{\text{bottom}} = \left(\frac{\mu_0 I}{2\pi d}, \text{out of page}\right)_{\text{top}} + \left(\frac{\mu_0 I}{2\pi d}, \text{into page}\right)_{\text{bottom}}$$

$$\Rightarrow B_{\text{at a}} = \frac{\mu_0 I}{2\pi}\left(\frac{1}{2.0\ \text{cm}} - \frac{1}{(4.0+2.0)\ \text{cm}}\right) = (2\times10^{-7}\ \text{T m/A})(10\ \text{A})\left(\frac{1}{2.0\times10^{-2}\ \text{m}} - \frac{1}{6.0\times10^{-2}\ \text{m}}\right)$$

$$\Rightarrow \vec{B}_{\text{at a}} = (6.7\times10^{-5}\ \text{T, out of page})$$

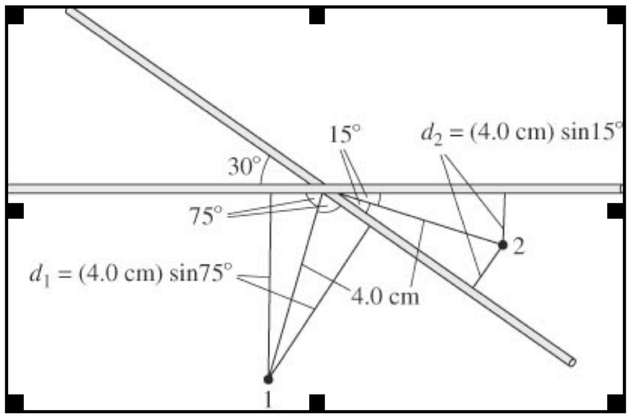
At points b and c,

$$\vec{B}_{\text{at 2}} = \left(\frac{\mu_0 I}{2\pi d}, \text{into page}\right) + \left(\frac{\mu_0 I}{2\pi d}, \text{into page}\right) = (2.0\times10^{-4}\ \text{T, into page})$$

$$\vec{B}_{\text{at 3}} = \left(\frac{\mu_0 I}{2\pi d}, \text{into page}\right) + \left(\frac{\mu_0 I}{2\pi d}, \text{out of page}\right) = (6.7\times10^{-5}\ \text{T, out of page})$$

33.43. Model: Assume that the wires are infinitely long and that the magnetic field is due to currents in both the wires.

Visualize: Point 1 is a distance d_1 away from the two wires and point 2 is a distant d_2 away from the two wires. A right triangle with a 75° degree angle is formed by a straight line from point 1 to the intersection and a line from point 1 that is perpendicular to the wire. Likewise, point 2 makes a 15° right triangle.



Solve: First we determine the distances d_1 and d_2 of the points from the two wires:

$$d_1 = (4.0\text{ cm})\sin 75° = 3.86\text{ cm} = 0.0386\text{ m}$$

$$d_2 = (4.0\text{ cm})\sin 15° = 1.04\text{ cm} = 0.0104\text{ m}$$

At point 1, the fields from both the wires point up and hence add. The total field is

$$B_1 = B_{\text{wire 1}} + B_{\text{wire 2}} = \frac{\mu_0}{2\pi}\frac{I_1}{d_1} + \frac{\mu_0}{2\pi}\frac{I_2}{d_1} = \frac{\mu_0}{\pi}\frac{(5.0\text{ A})}{d_1} = \frac{(4\times 10^{-7}\text{ T m/A})(5.0\text{ A})}{0.0386\text{ m}} = 5.2\times 10^{-5}\text{ T}$$

In vector form, $\vec{B}_1$ = (5.2 × 10^{-5} T, out of page). Using the right-hand rule at point 2, the fields are in opposite directions but equal in magnitude. So, $\vec{B}_2 = \vec{0}$ T.

33.53. Model: The magnetic field is that of a current in the wire.

Visualize: Please refer to Figure P33.53.

Solve: As given in Equation 33.6 for a current carrying small segment $\Delta\vec{s}$ the Biot-Savart law is

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{s}\times\hat{r}}{r^2}$$

For the straight sections, $\Delta\vec{s}\times\hat{r} = 0$ because both $\Delta\vec{s}$ and $\hat{r}$ point along the same line. That is not the case with the curved section over which $\Delta\vec{s}$ and $\hat{r}$ are perpendicular. Thus,

$$B = \frac{\mu_0}{4\pi}\frac{I\Delta s}{r^2} = \frac{\mu_0}{4\pi}\frac{IR\,d\theta}{R^2} = \frac{\mu_0 I\,d\theta}{4\pi R}$$

where we used $\Delta s = R\Delta\theta \approx R\,d\theta$ for the small arc length Δs. Integrating to obtain the total magnetic field at the center of the semicircle,

$$B = \int_{-\pi/2}^{\pi/2}\frac{\mu_0 I\,d\theta}{4\pi R} = \frac{\mu_0 I}{4\pi R}\pi = \frac{\mu_0 I}{4R}$$