Phys 202

Recitation 4

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Formulae

Magnetic field of a current-carrying wire:

$$B = \frac{\mu_0 I}{2\pi r}$$

Where the permeability of vacuum
$\mu_0 = 4\pi \times 10^{-7}$ T·m/A.

Magnetic field at the center of circular loop

$$B = \frac{\mu_0 I}{2R}.$$

If there are N windings, then

$$B = \frac{\mu_0 N I}{2R}$$

Force on a straight wire

In general, if the magnetic field B is not perpendicular to the current-carrying wire:

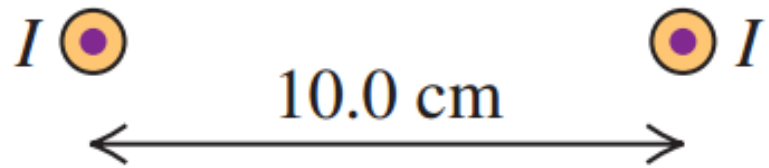
$$F = IlB_{\perp} = IlBsin\phi$$

59. • A closely wound circular coil has a radius of 6.00 cm and carries a current of 2.50 A. How many turns must it have if the magnetic field at its center is 6.39×10^{-4} T?

***20.59. Set Up:** The magnetic field at the center of N circular loops is $B = \dfrac{N\mu_0 I}{2R}$.

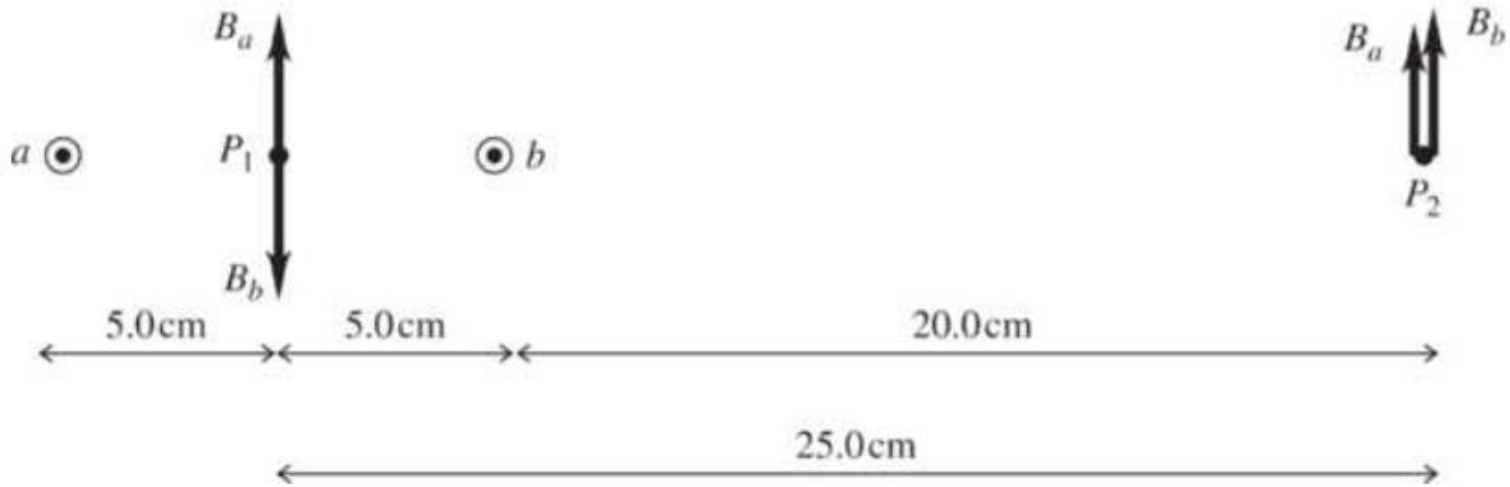
Solve: $N = \dfrac{2RB}{\mu_0 I} = \dfrac{2(6.00 \times 10^{-2}\ \text{m})(6.39 \times 10^{-4}\ \text{T})}{(4\pi \times 10^{-7}\ \text{T} \cdot \text{m/A})(2.50\ \text{A})} = 24.4$. Therefore, 24 turns are required.

51. ●● Two long, straight parallel wires are 10.0 cm apart and carry 4.00 A currents in the same direction (Figure 20.68). Find the magnitude and direction of the magnetic field at (a) point P_1, midway between the wires, (b) point P_2, 25.0 cm to the right of P_1.



▲ **FIGURE 20.68** Problem 51.

***20.51. Set Up:** $B = \dfrac{\mu_0 I}{2\pi r}$. The direction of $\vec{\boldsymbol{B}}$ is given by the right-hand rule in Section 20.7. Call the wires a and b, as indicated in the figure below. The magnetic fields of each wire at points P_1 and P_2 are also shown in the figure.



Solve: (a) At P_1, $B_a = B_b$ and the two fields are in opposite directions, so the net field is zero.

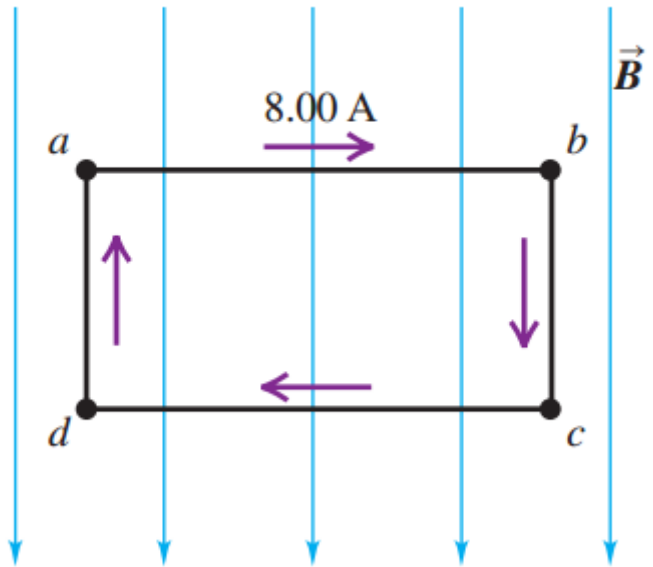
(b) $B_a = \dfrac{\mu_0 I}{2\pi r_a}$. $B_b = \dfrac{\mu_0 I}{2\pi r_b}$. $\vec{\boldsymbol{B}}_a$ and $\vec{\boldsymbol{B}}_b$ are in the same direction so

$$B = B_a + B_b = \frac{\mu_0 I}{2\pi}\left(\frac{1}{r_a} + \frac{1}{r_b}\right) = \frac{(4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A})(4.00\ A)}{2\pi}\left[\frac{1}{0.300\ \text{m}} + \frac{1}{0.200\ \text{m}}\right] = 6.67 \times 10^{-6}\ \text{T}$$

$\vec{\boldsymbol{B}}$ has magnitude $6.67\ \mu\text{T}$ and is directed toward the top of the page.

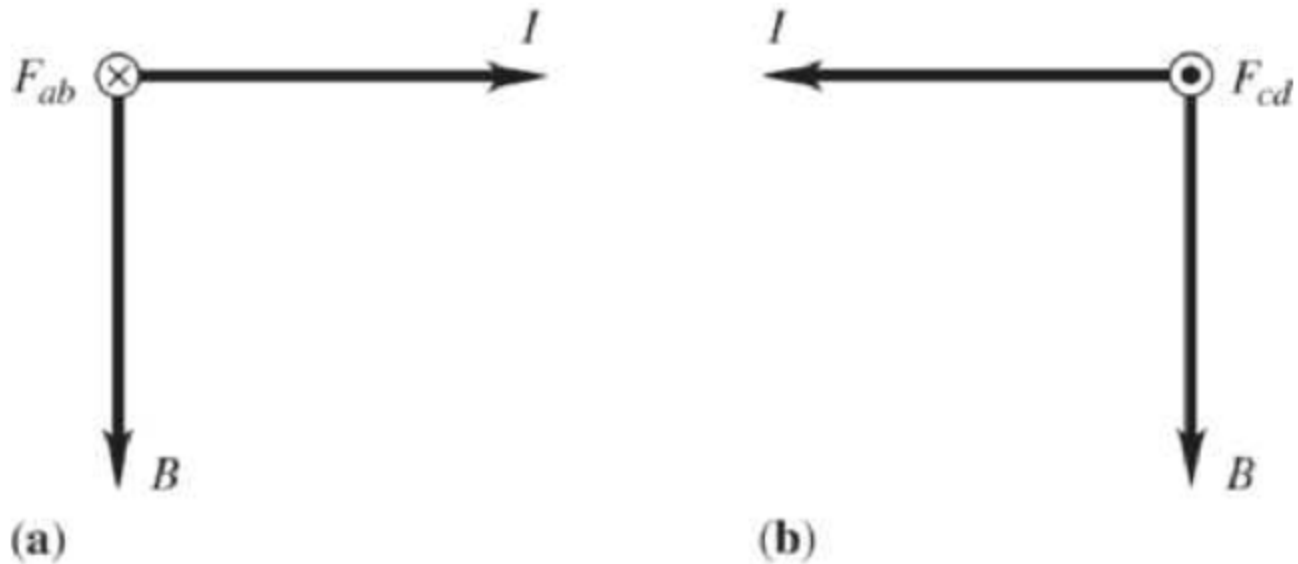
Reflect: At points directly to the left of both wires the net field is directed toward the bottom of the page.

31. • A rectangular 10.0 cm by 20.0 cm circuit carrying an 8.00 A current is oriented with its plane parallel to a uniform 0.750 T magnetic field (Figure 20.62). (a) Find the magnitude and direction of the magnetic force on each segment (ab, bc, etc.) of this circuit. Illustrate your answers with clear diagrams. (b) Find the magnitude of the net force on the entire circuit.



20.31. Set Up: $F = IlB\sin\phi$. The direction of $\vec{F}$ is given by the right-hand rule applied to the directions of I and $\vec{B}$.

Solve: (a) segment da: $\phi = 180°$ and $F = 0$ segment ab: $\phi = 90°$ and $F = IlB = (8.0\text{ A})(0.200\text{ m})(0.750\text{ T}) = 1.2\text{ N}$. The directions of I, $\vec{B}$, and $\vec{F}$ are shown in Figure (a) below. $\vec{F}$ is directed into the page. segment bc: $\phi = 0°$ and $F = 0$ segment cd: $\phi = 90°$ and $F = 1.2\text{ N}$. The directions of I, $\vec{B}$, and $\vec{F}$ are shown in Figure (b) below. $\vec{F}$ is directed out of the page.



(b) $\vec{F}_{ab}$ and $\vec{F}_{cd}$ are equal in magnitude and opposite in direction. Their vector sum is zero and the net force on the entire circuit is zero.

Reflect: The net force on any current loop in a uniform magnetic field is zero.

28. • A horizontal rod 0.200 m long carries a current through a uniform horizontal magnetic field of magnitude 0.067 T that points perpendicular to the rod. If the magnetic force on this rod is measured to be 0.13 N, what is the current flowing through the rod?