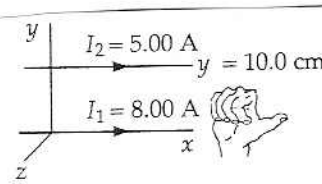
30.6 $B = \frac{\mu_0 I}{2R}$ $\quad R = \frac{\mu_0 I}{2B} = \frac{20.0\pi \times 10^{-7}}{2.00 \times 10^{-5}} = \boxed{31.4\text{ cm}}$

***30.16** Let both wires carry current in the x direction, the first at $y = 0$ and the second at $y = 10.0$ cm.



(a) $\mathbf{B} = \frac{\mu_0 I}{2\pi r}\mathbf{k} = \frac{(4\pi \times 10^{-7}\text{ T}\cdot\text{m/A})(5.00\text{ A})}{2\pi(0.100\text{ m})}\mathbf{k}$

$\mathbf{B} = \boxed{1.00 \times 10^{-5}\text{ T out of the page}}$

(b) $\mathbf{F}_B = I_2\mathbf{L}\times\mathbf{B} = (8.00\text{ A})\left[(1.00\text{ m})\mathbf{i}\times\left(1.00\times 10^{-5}\text{ T}\right)\mathbf{k}\right] = \left(8.00\times 10^{-5}\text{ N}\right)(-\mathbf{j})$

$\boxed{\mathbf{F}_B = 8.00 \times 10^{-5}\text{ N toward the first wire}}$

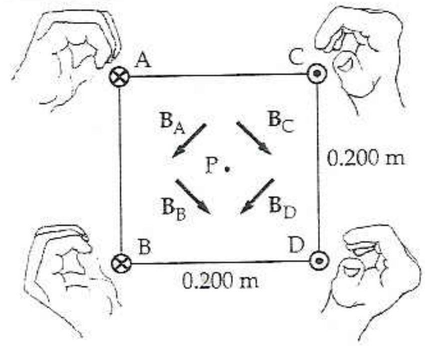
(c) $\mathbf{B} = \frac{\mu_0 I}{2\pi r}(-\mathbf{k}) = \frac{(4\pi \times 10^{-7}\text{ T}\cdot\text{m/A})(8.00\text{ A})}{2\pi(0.100\text{ m})}(-\mathbf{k}) = (1.60 \times 10^{-5}\text{ T})(-\mathbf{k})$

$\mathbf{B} = \boxed{1.60 \times 10^{-5}\text{ T into the page}}$

(d) $\mathbf{F}_B = I_1\mathbf{L}\times\mathbf{B} = (5.00\text{ A})\left[(1.00\text{ m})\mathbf{i}\times\left(1.60\times 10^{-5}\text{ T}\right)(-\mathbf{k})\right] = \left(8.00\times 10^{-5}\text{ N}\right)(+\mathbf{j})$

$\mathbf{F}_B = \boxed{8.00 \times 10^{-5}\text{ N toward the second wire}}$

30.19 Each wire is distant from P by (0.200 m) cos 45.0° = 0.141 m



Each wire produces a field at P of equal magnitude:

$$B_A = \frac{\mu_0 I}{2\pi a} = \frac{(2.00 \times 10^{-7}\text{ T}\cdot\text{m})(5.00\text{ A})}{\text{A}(0.141\text{ m})} = 7.07\ \mu\text{T}$$

Carrying currents into the page, A produces at P a field of 7.07 μT to the left and down at −135°, while B creates a field to the right and down at − 45°. Carrying currents toward you, C produces a field downward and to the right at − 45°, while D's contribution is downward and to the left. The total field is then

$4\,(7.07\ \mu\text{T}) \sin 45.0° = \boxed{20.0\ \mu\text{T}}$ toward the page's bottom

***30.22** (a) In $B = \frac{\mu_0 I}{2\pi r}$, the field will be one-tenth as large at a ten-times larger distance: $\boxed{400\text{ cm}}$

(b) $\mathbf{B} = \frac{\mu_0 I}{2\pi r_1}\mathbf{k} + \frac{\mu_0 I}{2\pi r_2}(-\mathbf{k})$ so $B = \frac{4\pi \times 10^{-7}\text{ T}\cdot\text{m}\,(2.00\text{ A})}{2\pi\text{ A}}\left(\frac{1}{0.3985\text{ m}} - \frac{1}{0.4015\text{ m}}\right) = \boxed{7.50\text{ nT}}$

(c) Call r the distance from cord center to field point and $2d$ = 3.00 mm the distance between conductors.

$$B = \frac{\mu_0 I}{2\pi}\left(\frac{1}{r-d} - \frac{1}{r+d}\right) = \frac{\mu_0 I}{2\pi}\frac{2d}{r^2 - d^2}$$

$$7.50 \times 10^{-10}\text{ T} = \left(2.00 \times 10^{-7}\ \frac{\text{T}\cdot\text{m}}{\text{A}}\right)(2.00\text{ A})\frac{(3.00 \times 10^{-3}\text{ m})}{r^2 - 2.25 \times 10^{-6}\text{ m}^2} \quad \text{so} \quad r = \boxed{1.26\text{ m}}$$

The field of the two-conductor cord is weak to start with and falls off rapidly with distance.

(d) The cable creates $\boxed{\text{zero}}$ field at exterior points, since a loop in Ampère's law encloses zero total current. Shall we sell coaxial-cable power cords to people who worry about biological damage from weak magnetic fields?

30.31 The resistance of the wire is $R_e = \frac{\rho \ell}{\pi r^2}$, so it carries current $I = \frac{\mathcal{E}}{R_e} = \frac{\mathcal{E}\pi r^2}{\rho \ell}$.

If there is a single layer of windings, the number of turns per length is the reciprocal of the wire diameter: $n = 1/2r$.

So, $B = n\mu_0 I = \frac{\mu_0 \mathcal{E}\pi r^2}{\rho\,\ell\,2r} = \frac{\mu_0 \mathcal{E}\pi r}{2\rho\,\ell} = \frac{(4\pi \times 10^{-7}\text{ T}\cdot\text{m/A})(20.0\text{ V})\pi\,(2.00 \times 10^{-3}\text{ m})}{2(1.70 \times 10^{-8}\ \Omega\cdot\text{m})(10.0\text{ m})} = \boxed{464\text{ mT}}$