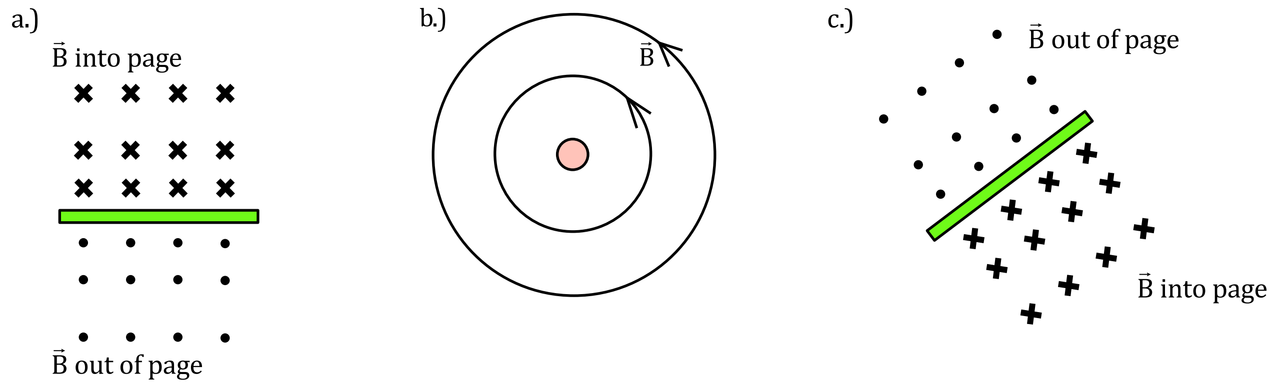
30-Series Problem (Sources of B-flds)

30.2) The magnetic fields shown are all produced by current-carrying wires. For each situation, determine the direction of current required to produce the B-fld shown.



30.3) A long wire carries a current of 2.00 A. Determine the magnitude of the magnetic field it produces 25.0 cm away.

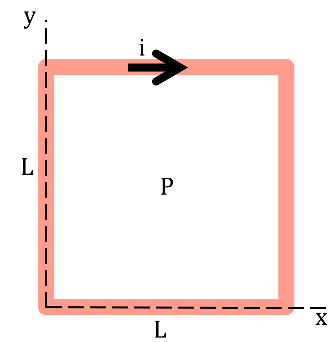
30.4) (This problem should be done after Problem 30.13.) The 1913 model of the atom postulated by Niels Bohr (called *the Bohr atom*) suggests that the electrons of an atom circle the nucleus in very specific energy orbitals at very specific radii. The Bohr model for a hydrogen atom, therefore, is just an electron circling a proton. If the radius of hydrogen atom is $5.29\text{x}10^{-11}$ m (i.e., it's diameter is approximately 1 angstrom, which I include here only because the word *angstrom* is so cool . . . it is, by the way, defined as 10^{-10} m), and if the electron is assumed to be moving with a speed of $2.19\text{x}10^{6}$ m/s (this is a hair under 5,000,000 mph), what magnetic field (direction and magnitude) would the circling electron produce at the center of its motion (i.e., where the proton resides). (Huge note: This problem can be approximated as the magnetic field down the axis of a current carrying loop of wire, albeit a loop with only one electron moving through it, but a loop nevertheless—use the law of Biot-Savart to derive your expression—the derivation should produce the expression $B=\frac{\mu_o i}{2R}$.) (Second Note: You will be asked to do a much more difficult version of this problem later—like next—it's educational).

30.4 *the hard way*) Redo Problem 30.4, but start with the assumption you are looking at a coil of wire. Use Biot-Savart to derive the magnetic field function (with direction) down the axis of the coil, then let the length of the coil go to zero to bring the problem back to the actual Problem 30.4. (Note: This is going to seem hard, but by the time you are done you should REALLY understand both what the variables in Biot-Savart stand for and how the direction of a differential B-fld is defined).

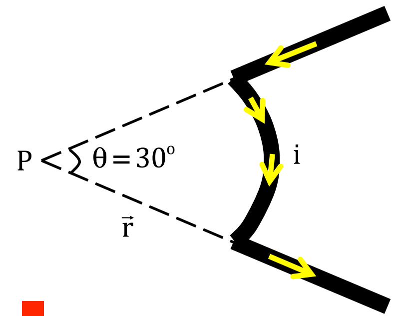
30.5) A square loop of edge-length L = 0.400 m carries current i = 10.0 A in a clockwise direction, as shown in the sketch.

a.) Determine the magnitude and direction of the B-fld produced down the central axis of the loop (that is, at *Point P* at the center of the square).

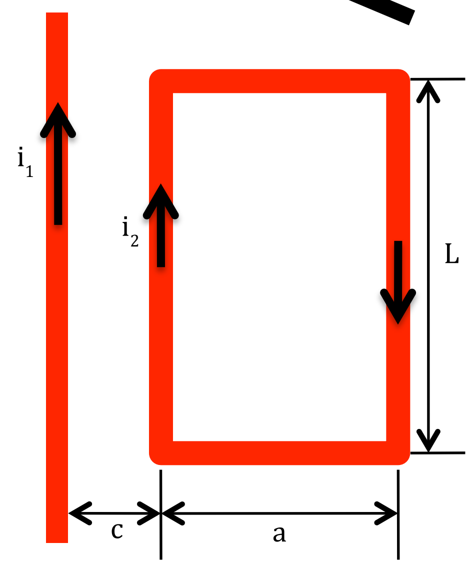
b.) Determine the magnitude and direction of the B-fld if the loop carried the same current but was reshaped into a circle of circumference 4d.



30.13) Consider the oddly shaped current-carrying wire as shown to the right (it consists of two straight and one curved section). If the current through the wire is 3.00 A and the radius of the arc is 0.600 m, what must the magnetic field (direction and magnitude) be at *Point P* (i.e., at the center of the curved wire's arc)?



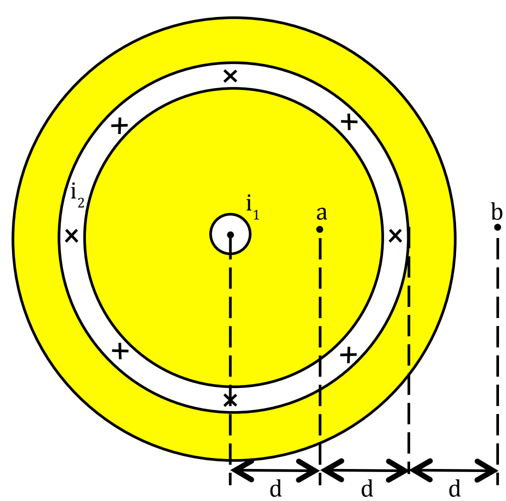
30.23) A rectangular loop carries a current $i_2 = 10.0$ A. Next to the wire runs a second wire whose current is $i_1 = 5.00$ A. Distances are $a = 0.150$ m, $c = 0.100$ m and $L = 0.450$ m. What is the magnitude and direction of the *magnetic force* on the loop generated by the presence of the wire?



30.29) To the right is shown the cross-section of a coaxial cable. The central wire, with current coming *out of the page* in the amount $i_1 = 1.00$ A, is surrounded by a layer of insulating rubber. This insulation goes out to an outer, cylindrically shaped conductor in which there is current going *into the page* of the amount $i_2 = 3.00$ A. Outside this outer conductor is more rubber. If *d* in the sketch is defined as d = 1.00 mm:

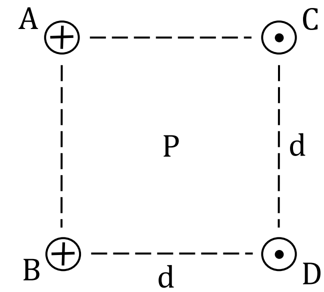
a.) What is the magnitude and direction of the B-fld at *Point a*?

b.) What is the magnitude and direction of the B-fld at *Point b*?



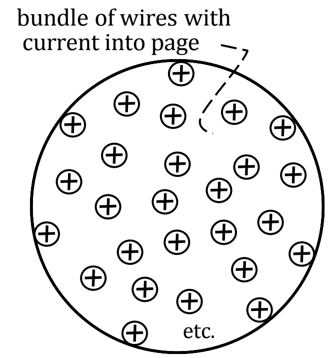
30.32) Four wire each carrying a current I = 5.00 A are parallel to one another and located so as to form a square (as viewed from an end) where the wires are d = 0.200 m apart (see sketch). Wires *A* and *B* have current flowing *into* the page while wires *C* and *D* have current flowing *out of* the page. *Point P* is located at the center of the square (again, look at the sketch).

- a.) Determine the magnitude of the B-fld at *Point P*.
- b.) Determine the direction of the B-fld at *Point P*.

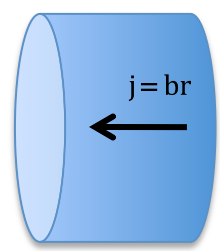


30.34) The sketch to the right shows a cross-section of a closely packed bundle of long, straight wires (100 of them) each with current of I = 2.00 A flowing through them *into the page*. The outside radius of the bundle is 0.500 cm.

- a.) What is the magnitude of the *magnetic force* on a wire 0.200 cm from the center of the bundle?
- b.) What is the direction of the magnetic force on the wire alluded to in *Part a*?
- c.) What, if anything, would have been different if the wire had been located at the edge of the bundle? Justify your response qualitatively.



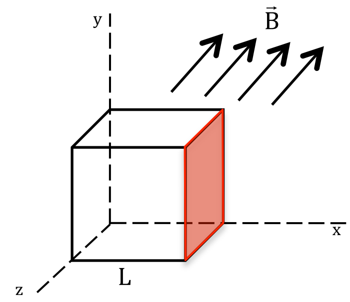
30.36) A long, cylindrical conductor carries a varying current density across its cross-section equal to $J = br$, where b is a positive constant and r is measured out from the central axis of the conductor (note that the consequence of this density function is that down the axis where $r = 0$, there is no current flow). The total current being carried by the conductor is I and the radius of the conductor is R.



- a.) Derive an expression for the B-fld that exists r units out from the central axis, where $r < R$. (Note that the variable r is being used in two different contexts here. This is not unusual for problems like this, where a density function needs to allude to a distance from the central axis of a structure (that's the $J = br$ term) and a derived quantity like $B(r)$ also needs to be defined from a central axis.)
- b.) Derive an expression for the B-fld that exists r units out from the central axis, where $r > R$.

30.39) A 1000 turn solenoid of length L = 0.400 m produces a B-fld of 1.00×10^{-4} T down its central axis. How much current was required to produce that B-fld?

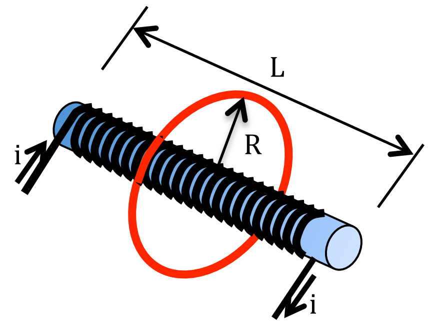
30.45) A magnetic field equal to $\vec{B} = \left(5\hat{i} + 4\hat{j} + 3\hat{k}\right)T$ exists in a region in which a cube with sides equal to L = 2.50 cm also resides, as shown in the sketch.



a.) What is the magnetic flux through the shaded area of the cube?

b.) Determine the total flux through the entire cube.

30.47) A 300 turn solenoid of length L = 30.0 cm and radius r = 1.25 cm has a current i = 12.0 A flowing through it. A circular area is bounded by a wire of radius R = 5.00 cm that is positioned perpendicular to and centered on the solenoid's central axis.



a.) Determine the magnetic flux that exists through the circular wire of radius R.

b.) Forget about the circular wire of radius R. Looking down the axis of the solenoid in the enlarged view shown below (remember, the solenoid's radius is *r*), there is a yellow region internal to the solenoid whose inner radius is *a* and whose outer radius is *b*. Determine the magnetic flux through the yellow region.