University Physics II

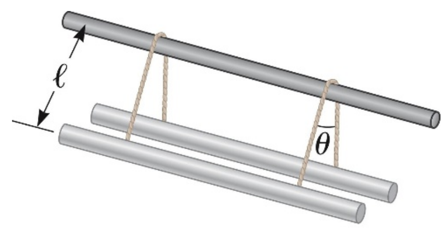
Homework Set 10

1. Two parallel wires are separated by 6.00 *cm*, each carrying 3.00 A of current in the same direction.
   - *a.* What is the magnitude of the force per unit length between the wires?
   - *b.* Is the force attractive or repulsive?

2. Two long, parallel conductors, separated by 10.0 *cm*, carry currents in the same direction. The first wire carries a current $I_1 =$ 5.00 A, and the second carries $I_2 =$ 8.00 A.
   - *a.* What is the magnitude of the magnetic field created by I_1 at the location of I_2?
   - *b.* What is the force per unit length exerted by I_1 on I_2?
   - *c.* What is the magnitude of the magnetic field created by I_2 at the location of I_1?
   - *d.* What is the force per unit length exerted by I_2 on I_1?

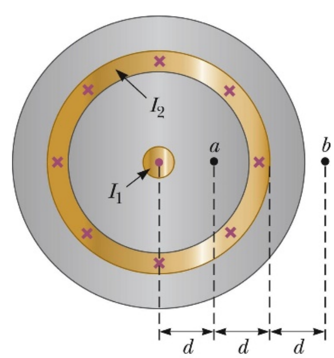
3. Two long, parallel wires are attracted to each other by a force per unit length of 320 μN/*m*. One wire carries a current of 20.0 A to the right and is located along the line $y = 0.500$ *m*. The second wire lies along the x axis ($y = 0$).
   - *a.* What is the current in the second wire?
   - *b.* Determine the value of y between the wires in which the total magnetic field is zero.

4. The unit of magnetic flux is named for Wilhelm Weber. A practical-size unit for the magnetic field is named for Johann Karl Friedrich Gauss. Along with their individual accomplishments, Weber and Gauss built a telegraph in 1833 that consisted of a battery and a switch at one end of a 3 *km* transmission line that operated an electromagnet at the other end. Suppose their transmission line was as diagrammed as shown at right. Two long, parallel wires, each having a mass per unit length of 40.0 *g*/*m*, are supported in a horizontal plane by strings $l = 6.00$ *cm* long. When both wires carry the same current I, the wires repel each other so that the angle between the supporting strings is $\theta = 16.0^{o}$.

   - *a.* Are the currents in the same or opposite directions?
   - *b.* Find the magnitude of the current.
   - *c.* If the transmission line were taken to the surface of Mars, would the current required to separate the wires by the same angle be larger or smaller than that required on the Earth? Explain.

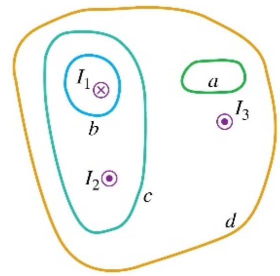
5. A cross-sectional view of a coaxial cable is shown at right. The center conductor is surrounded by a rubber layer, an outer conductor, and another rubber layer. In a particular application, the current in the inner conductor is $I_1 = 1.00$ A out of the page and the current in the outer conductor is $I_2 = 3.00$ A into the page. Assuming the distance $d = 1.00$ *mm*, determine:

   - *a.* The magnitude and direction of the magnetic field at point *a*
   - *b.* The magnitude and direction of the magnetic field at point *b*

6. The magnetic coils of a tokamak fusion reactor are in the shape of a toroid having an inner radius of 0.700 *m* and an outer radius of 1.30 *m*. The toroid has 900 *turns* of large-diameter wire, each of which carries a current of 14.0 kA. Find the magnitude of the magnetic field inside the toroid along:
   a. The inner radius
   b. The outer radius

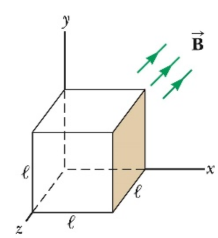
7. The figure at right shows, in cross-section, several wire conductors through the plane of the page. The currents have magnitudes $I_1 = 4.0$ A, $I_2 = 6.0$ A, and $I_3 = 2.0$ A in the directions indicated. Four paths, labeled *a* through *d*, are also shown. What is the line integral $\oint \vec{B} \cdot d\vec{l}$ for each path? Assume each integral involves going around the shown path in the counter-clockwise direction.



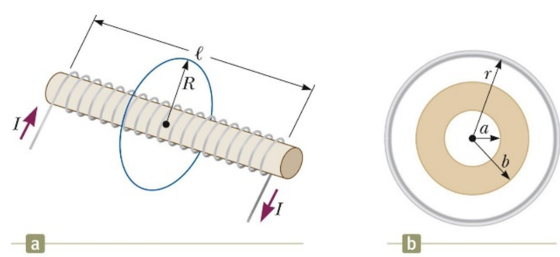
8. A continuous magnetic field of 45.0 T has been achieved at Florida State University's National High Magnetic Field Laboratory in Tallahassee, Florida. Find the current needed to achieve such a field:
   a. 2.00 *cm* from a long, straight wire
   b. At the center of a circular coil of radius 42.0 *cm* that has 100 *turns*
   c. Near the center of a solenoid with radius 2.40 *cm*, length 32.0 *cm*, and 40,000 *turns*.

9. The magnetic field 40.0 *cm* away from a long, straight wire is 1.00 μT. At what distance is the magnetic field 0.100 μT?

10. A cube of edge length $l = 2.50$ *cm* is positioned as shown in the figure at right. A uniform magnetic field, given by $\vec{B} = (5\hat{x} + 4\hat{y} + 3\hat{z})$ T exists throughout the region.
    a. Calculate the magnetic flux through the shaded surface.
    b. What is the total flux through the six faces?

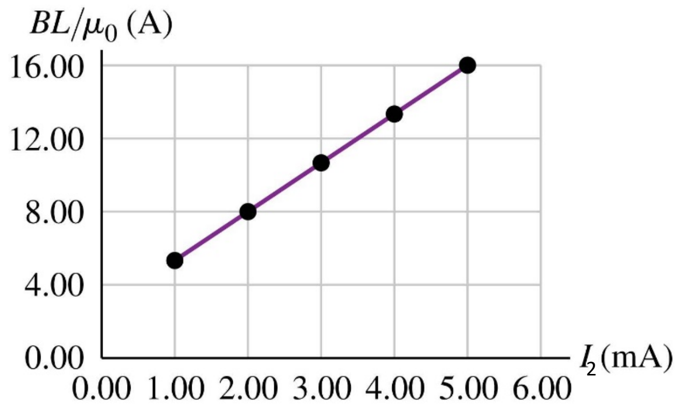


11. A solenoid of radius $r = 1.25$ *cm* and length $l = 30.0$ *cm* has 300 *turns* and carries 12.0 A.
    a. Calculate the flux through the surface of a disk-shaped area of radius $R = 5.00$ *cm* that is positioned perpendicular to and centered on the axis of the solenoid as shown in the figure at right (figure *a*).



    b. Figure *b* shows an enlarged end view of the same solenoid. Calculate the flux through the tan area, which is an annulus with an inner radius of $a = 0.400$ *cm* and an outer radius of $b = 0.800$ *cm*.

12. As a summer intern at a research lab, you are given a long solenoid that has two separate windings that are wound close together, in the same direction, and on the same hollow cylindrical tube. You must determine the number of turns in each winding. The solenoid has length L = 40.0 *cm* and diameter 2.80 *cm*. You let a I_1 = 2.00 *m*A current flow in winding 1 and vary the current I_2 in winding 2. Both currents flow in the same direction. You then measure the magnetic field magnitude B at the center of the solenoid as a function of I_2. You plot your results as BL/μ_o vs. I_2. The graph below shows your data along with the best-fit straight line to your data.



a. Find an equation for BL/μ_o in terms of I_2 to explain why the data plotted in this way should fall close to a straight line.

Hint: The total magnetic field is the sum of the magnetic fields of the two windings as if they were separate solenoids: $B = B_1 + B_2$.

b. Use your graph to find the equation for the best fit line so that you can calculate N_1 and N_2, the number of turns in winding 1 and 2, respectively.

c. If the current I_1 remained 2.00 *m*A in its original direction in winding 1 and winding 2 had a current I_2 = 5.00 *m*A in the opposite direction, what is the magnitude of B at the center of the solenoid?