44. (II) Two long straight parallel wires are 15 cm apart. Wire A carries 2.0 A current. Wire B's current is 4.0 A in the same direction. (*a*) Determine the magnetic field magnitude due to wire A at the position of wire B. (*b*) Determine the magnetic field due to wire B at the position of wire A. (*c*) Are these two magnetic fields equal and opposite? Why or why not? (*d*) Determine the force on wire A due to wire B, and the force on wire B due to wire A. Are these two forces equal and opposite? Why or why not?

45. (II) Three long parallel wires are 3.8 cm from one another. (Looking along them, they are at three corners of an equilateral triangle.) The current in each wire is 8.00 A, but its direction in wire M is opposite to that in wires N and P (Fig. 20–60). Determine the magnetic force per unit length on each wire due to the other two.

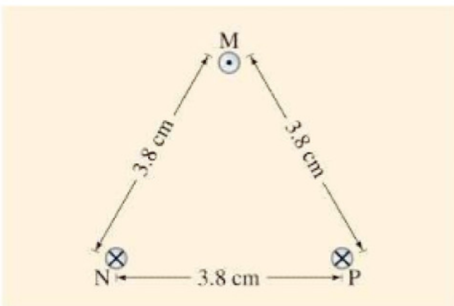

FIGURE 20–60 Problems 45, 46, and 74.

46. (II) In Fig. 20–60, determine the magnitude and direction of the magnetic field at the midpoint of the side of the triangle between wire M and wire N.

47. (II) Let two long parallel wires, a distance d apart, carry equal currents I in the same direction. One wire is at $x = 0$, the other is at $x = d$, Fig. 20–61. Determine $\vec{\mathbf{B}}$ along the x axis between the wires as a function of x.

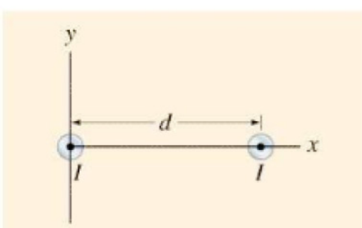

FIGURE 20–61 Problem 47.

20–7 Solenoids and Electromagnets

48. (I) A thin 12-cm-long solenoid has a total of 420 turns of wire and carries a current of 2.0 A. Calculate the field inside near the center.

49. (I) A 30.0-cm long solenoid 1.25 cm in diameter is to produce a field of 0.385 T at its center. How much current should the solenoid carry if it has 975 turns of the wire?

50. (II) A 550-turn solenoid is 15 cm long. The current in it is 33 A. A 3.0-cm-long straight wire cuts through the center of the solenoid, along a diameter. This wire carries a 22-A current downward (and is connected by other wires that don't concern us). What is the force on this wire assuming the solenoid's field points due east?

51. (III) You have 1.0 kg of copper and want to make a practical solenoid that produces the greatest possible magnetic field for a given voltage. Should you make your copper wire long and thin, short and fat, or something else? Consider other variables, such as solenoid diameter, length, and so on.

* 20–8 Ampère's Law

*** 52.** (II) A toroid is a solenoid in the shape of a circle (Fig. 20–62). Use Ampère's law along the circular path, shown dashed in Fig. 20–62a, to determine that the magnetic field (*a*) inside the toroid is $B = \mu_0 NI/2\pi R$, where N is the total number of turns, and (*b*) outside the toroid is $B = 0$. (*c*) Is the field inside a toroid uniform like a solenoid's? If not, how does it vary?

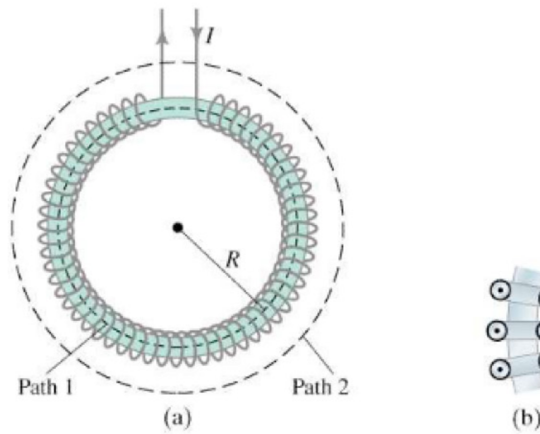

FIGURE 20–62 Problem 52. (a) A toroid. (b) A section of the toroid showing direction of the current for three loops: ⊙ means current toward you, and ⊗ means current away from you.

*** 53.** (III) (*a*) Use Ampère's law to show that the magnetic field between the conductors of a *coaxial cable* (Fig. 20–63) is $B = \mu_0 I/2\pi r$ if r is greater than the radius of the inner wire and less than the radius of the outer cylindrical braid. (*b*) Show that $B = 0$ outside the coaxial cable.

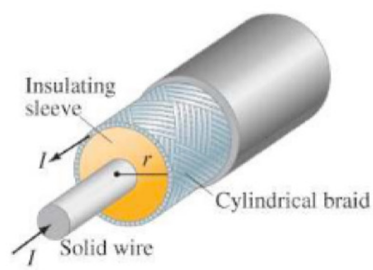

FIGURE 20–63 Coaxial cable. Problem 53.

* 20–9 and 20–10 Torque on Current Loop, Applications

*** 54.** (I) A single square loop of wire 22.0 cm on a side is placed with its face parallel to the magnetic field between the pole pieces of a large magnet. When 6.30 A flows in the coil, the torque on it is 0.325 m·N. What is the magnetic field strength?