

1. The unit of magnetic flux is named for Wilhelm Weber. The practical-size unit of magnetic field is named for Johann Karl Friedrich Gauss. Both were scientists at Gottingen, Germany. Along with their individual accomplishments, together they built a telegraph in 1833. It consisted of a battery and switch, at one end of a transmission line 3 km long, operating an electromagnet at the other end. (André Ampère suggested electrical signaling in 1821; Samuel Morse built a telegraph line between Baltimore and Washington in 1844.) Suppose that Weber and Gauss's transmission line was as diagrammed in Fig. 1. Two long, parallel wires, each having a mass per unit length of 40.0 g/m, are supported in a horizontal plane by strings 6.00 cm long. When both wires carry the same current I , the wires repel each other so that the angle θ between the supporting strings is 16.0° . (i) Are the currents in the same direction or in opposite directions? (ii) Find the magnitude of the current.

2. Figure 2 is a cross-sectional view of a coaxial cable. The center conductor is surrounded by a rubber layer, which is surrounded by an outer conductor, which is surrounded by another rubber layer. In a particular application, the current in the inner conductor is 1.00 A out of the page and the current in the outer conductor is 3.00 A into the page. Determine the magnitude and direction of the magnetic field at points a and b .

3. A long cylindrical conductor of radius R carries a current I as shown in Fig. 3. The current density J , however, is not uniform over the cross section of the conductor but is a function of the radius according to $J = br$, where b is a constant. Find an expression for the magnetic field B (i) at a distance $r_1 < R$ and (ii) at a distance $r_2 > R$, measured from the axis.

4. A toroid with a mean radius of 20.0 cm and 630 turns is filled with powdered steel whose magnetic susceptibility χ is 100. The current in the windings is 3.00 A. Find B (assumed uniform) inside the toroid.

5. In Bohr's 1913 model of the hydrogen atom, the electron is in a circular orbit of radius 5.29×10^{-11} m and its speed is 2.19×10^6 m/s. (i) What is the magnitude of the magnetic moment due to the electron's motion? (ii) If the electron moves in a horizontal circle, counterclockwise as seen from above, what is the direction of this magnetic moment vector?

6. The magnetic moment of the Earth is approximately 8.00×10^{22} A \cdot m². (i) If this were caused by the complete magnetization of a huge iron deposit, how many unpaired electrons would this correspond to? (ii) At two unpaired electrons per iron atom, how many kilograms of iron would this correspond to? [*Hint*: Iron has a density of 7,900 kg/m³, and approximately 8.50×10^{28} iron atoms/m³.]

7. Find the magnetic field on the axis at a distance a above a disk of radius R with charge density σ rotating at an angular speed (clockwise when viewed from the point P).

8. A thin uniform ring of radius R and mass M carrying a charge $+Q$ rotates about its axis with constant angular speed ω . Find the ratio of the magnitudes of its magnetic dipole moment to its angular momentum. (This is called the gyromagnetic ratio.)

9. A wire ring lying in the xy -plane with its center at the origin carries a counterclockwise I .

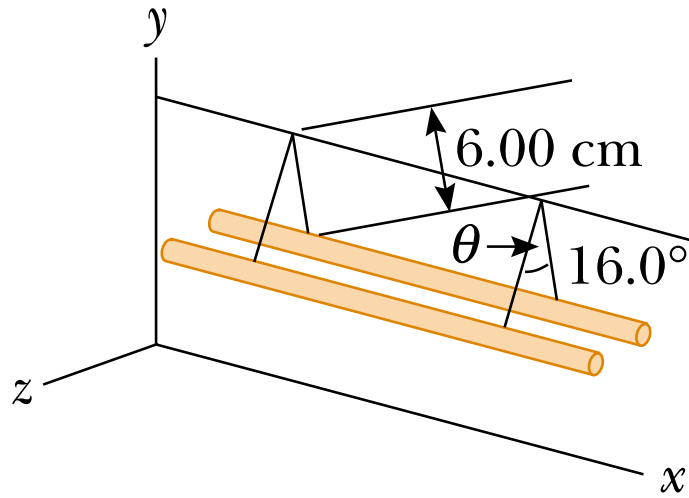


Figure 1: Problem 1.

There is a uniform magnetic field $\vec{B} = B\hat{i}$ in the $+x$ -direction. The magnetic moment vector μ is perpendicular to the plane of the loop and has magnitude $\mu = IA$ and the direction is given by right-hand-rule with respect to the direction of the current. What is the torque on the loop?

10. A square coil with sides equal to 25.0 cm carries a current of 2.00 A. It lies in the $z = 0$ plane in a magnetic field $\vec{B} = 0.40\hat{i} + 0.30\hat{k}$ T with the current counter-clockwise when viewed from a point on the positive z -axis. If the coil has 6 turns what is (i) the torque acting on the coil, and (ii) the potential energy of the coil/field system?

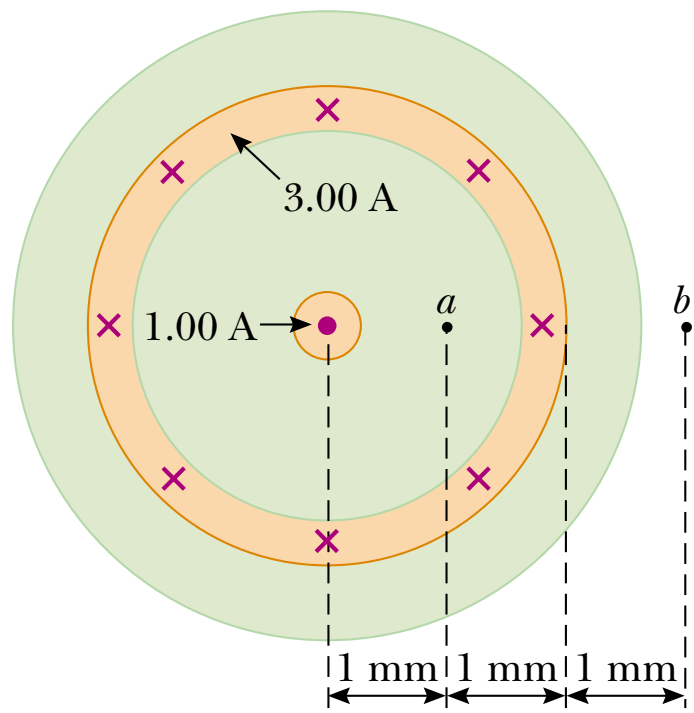


Figure 2: Problem 2.

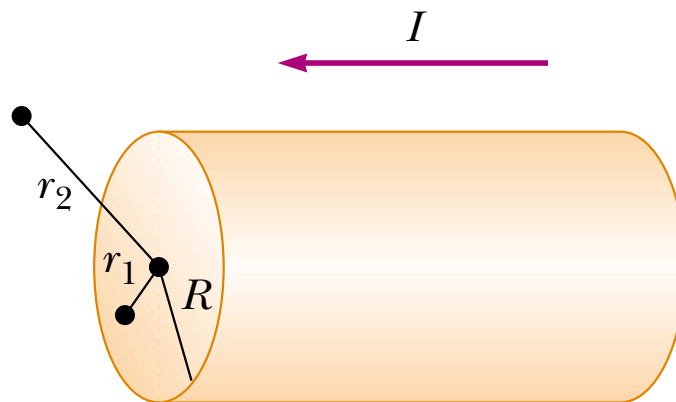


Figure 3: Problem 3.