Prof. Anchordoqui

**Problems set # 8** **Physics 167** April 4, 2023

1. A particle of charge $-e$ is moving with an initial velocity $v$ when it enters midway between two plates where there exists a uniform magnetic field pointing into the page, as shown in Fig. 1. You may ignore effects of the gravitational force. *(i)* Is the trajectory of the particle deflected upward or downward? *(ii)* What is the magnitude of the velocity of the particle if it just strikes the end of the plate?

2. The entire $x - y$ plane to the right of the origin $O$ is filled with a uniform magnetic field of magnitude $B$ pointing out of the page, as shown in Fig. 2. Two charged particles travel along the negative $x$ axis in the positive $x$ direction, each with velocity $\vec{v}$, and enter the magnetic field at the origin $O$. The two particles have the same mass $m$, but have different charges, $q_1$ and $q_2$. When propagate thorugh the magnetic field, their trajectories both curve in the same direction (see sketch in Fig. 2), but describe semi-circles with different radii. The radius of the semi-circle traced out by particle 2 is exactly twice as big as the radius of the semi-circle traced out by particle 1. *(i)* Are the charges of these particles positive or negative? Explain your reasoning. *(ii)* What is the ratio $q_2/q_1$?

3. Shown in Fig. 3 are the essentials of a commercial mass spectrometer. This device is used to measure the composition of gas samples, by measuring the abundance of species of different masses. An ion of mass m and charge $q = +e$ is produced in source $S$, a chamber in which a gas discharge is taking place. The initially stationary ion leaves $S$, is accelerated by a potential difference $\Delta V > 0$, and then enters a selector chamber, $S_1$, in which there is an adjustable magnetic field $\vec{B}_1$, pointing out of the page and a deflecting electric field $\vec{E}$, pointing from positive to negative plate. Only particles of a uniform velocity $\vec{v}$ leave the selector. The emerging particles at $S_2$, enter a second magnetic field $B_2$, also pointing out of the page. The particle then moves in a semicircle, striking an electronic sensor at a distance $x$ from the entry slit. Express your answers to the questions below in terms of $E \equiv |\vec{E}|$, $e$, $x$, $m$, $B_2 \equiv |\vec{B}_2|$, and $\Delta V$. *(i)* What magnetic field $B_1$ in the selector chamber is needed to insure that the particle travels straight through? *(ii)* Find an expression for the mass of the particle after it has hit the electronic sensor at a distance $x$ from the entry slit.

4. 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 Göttingen, 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 Ampérè 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. 4. 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 $\theta$ 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.

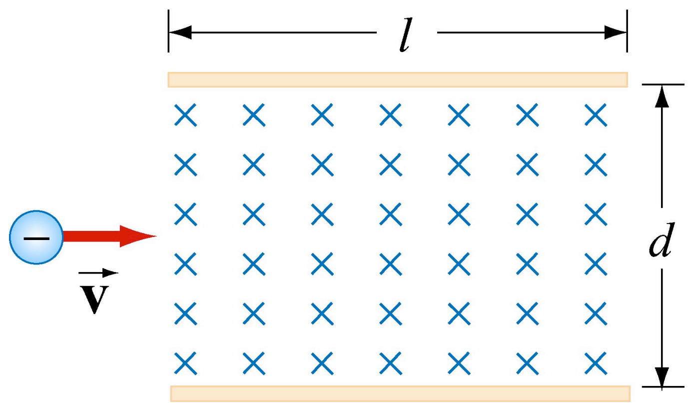


Figure 1: Problem 1.

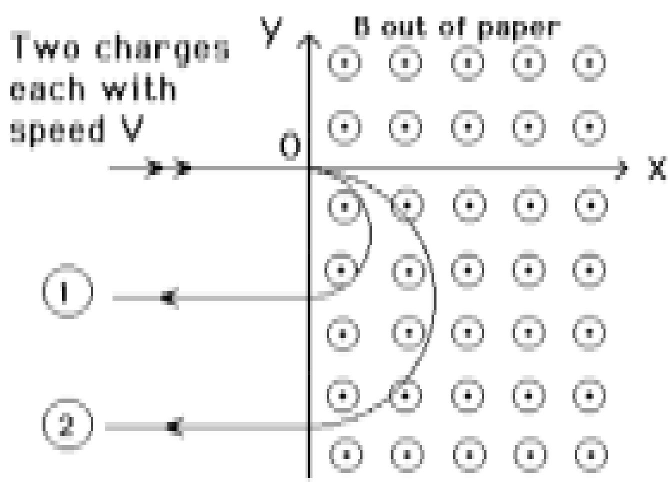


Figure 2: Problem 2.

5. Figure 5 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 $b$.

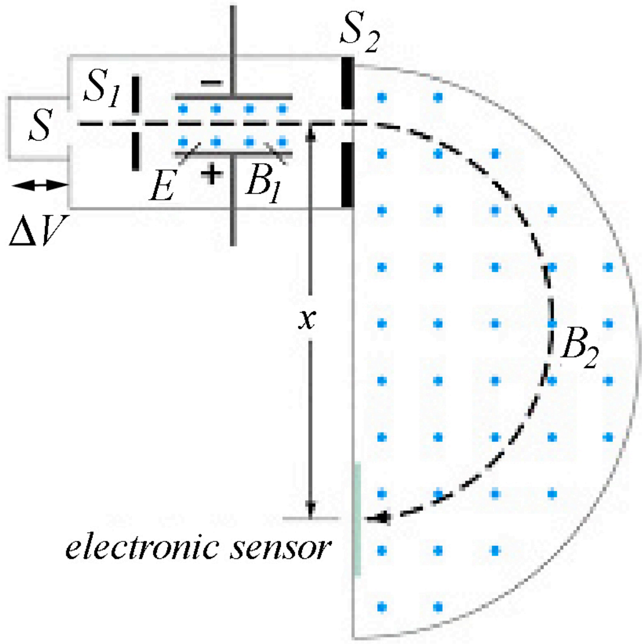


Figure 3: Problem 3.

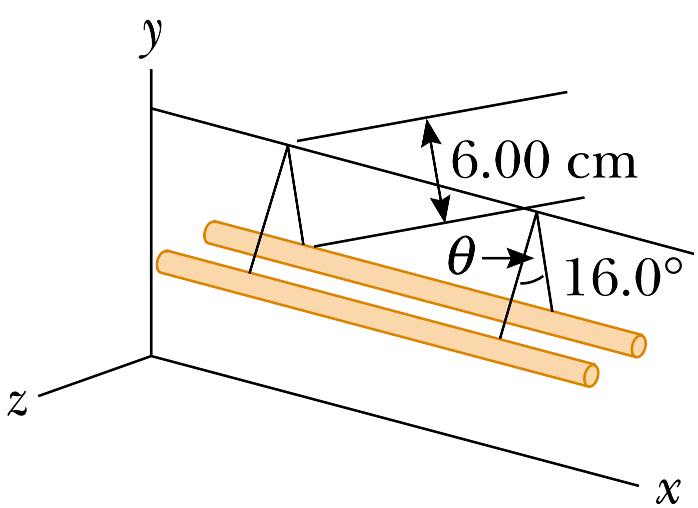


Figure 4: Problem 4.

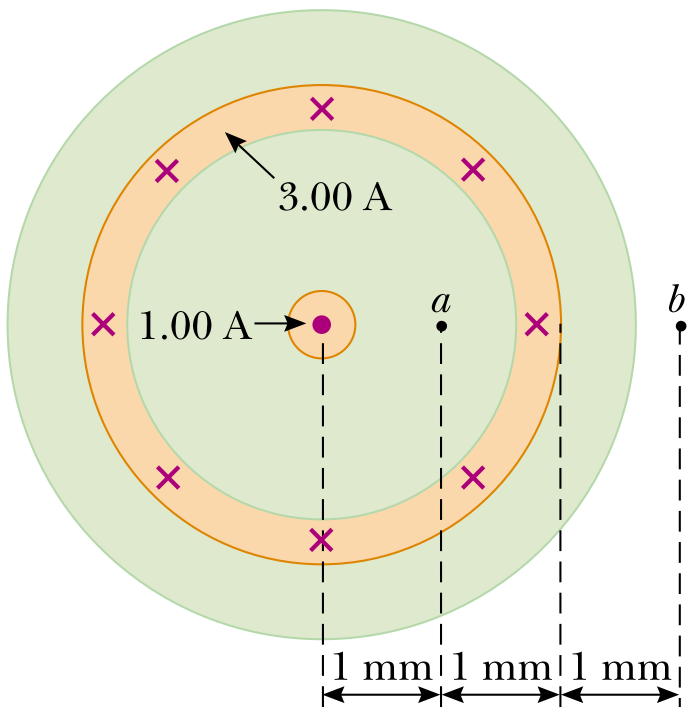


Figure 5: Problem 5.