

8.02X Electricity and Magnetism

~~Problem Set 7~~

~~Issued: Thu, March 24~~

~~Due: Mon, April 4, 4PM <- note Date & Time!~~

~~Reading suggestions (from Young & Freedman)~~

~~Mon, 3/28 Magnetic Field, Lorentz Force~~

~~Wed, 3/30 Source of Magnetic Fields, Law of Biot-Savart~~

~~Fri, 4/1 Ampere's Law~~

~~Note that the next experiment is EB (Electric Breakdown). The EB questions will be posted in a separate document. The EB experiment will be due on Monday, April 4.~~

Problem 1 (5 points):

A charged particle is moving through a uniform magnetic field. If an electric field that points in the same direction as the magnetic field is turned on, describe the path the charged particle will take (use a sketch).

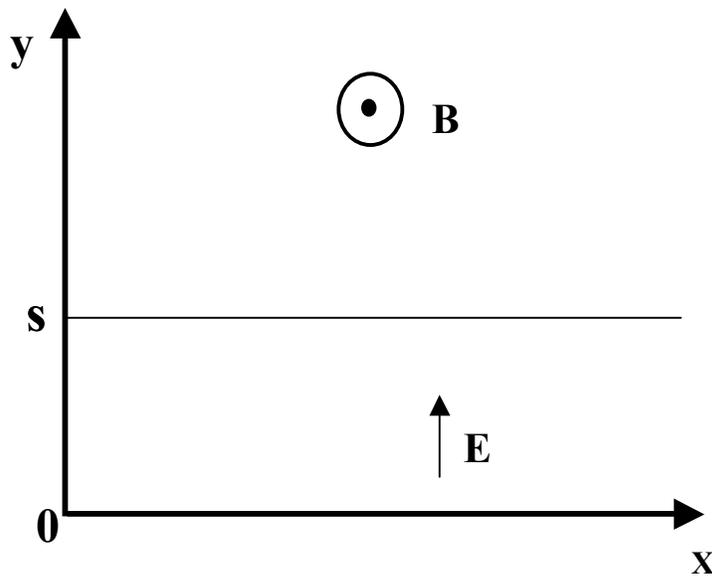
Problem 2 (5 points):

Can you set a resting electron into motion with a constant magnetic field? Explain how (or why not).

Problem 3 (10 points):

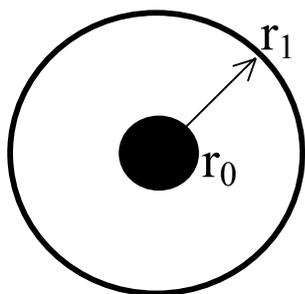
See drawing: An ion of mass M and charge q is initially at rest at the origin ($x=0$) at $t=0$. A region of uniform electric field E pointing in the y direction extends from $y=0$ to $y=s$. Above $y=s$, there is a region of magnetic field B , pointing in the z direction.

- When and where does the ion first cross the x - z plane located at $y=s$?
- What is the ion's trajectory in the B -field region? Where does it cross the x - z plane at $y=s$ for the second time?
- Where does the ion come to rest?



Problem 4 (10 points):

Shown below is the cross section of a long coaxial cable consisting of an inner core with radius r_0 and an outer shell of radius r_1 , both centered at $r=0$. The inner core carries a current I going into the paper plane, the outer shell carries the same current I in the opposite direction. Using Ampere's law, find the magnitude of the magnetic field $B(r)$ in the region $r_0 < r < r_1$ and $r > r_1$.

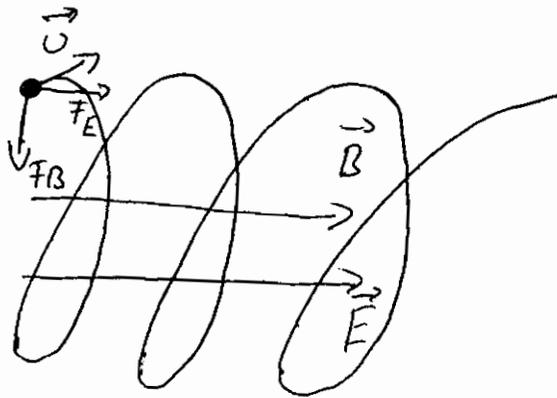


Solutions

8.02x SP05

Pset 7

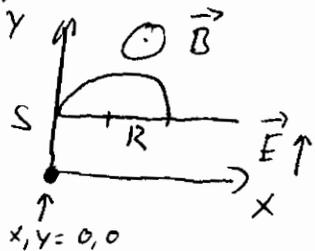
1)



Particle will move on a helical trajectory, accelerating in the direction of \vec{E}

- 2) No. \vec{F}_B is 0 if $\vec{v} = 0$. More generally, a magnetic field does no work, as $\vec{F}_B \perp \vec{v}$.
 constant

3)



- a) Particle will be accelerated straight up \rightarrow crosses plane at $x, y = 0, s$
 b) Particle will move on a semi-circle.

Energy is $q \cdot E \cdot s$, momentum therefore $P = \sqrt{2 \cdot K \cdot M} = \sqrt{q \cdot 2 \cdot E \cdot s \cdot M}$

$$\Rightarrow R = \frac{P}{q \cdot B} = \frac{\sqrt{2 E s M}}{\sqrt{q} \cdot B}$$

\Rightarrow Coordinate for crossing x, z plane is $(2R, s)$

c) At $(2R, 0)$.