Week 12, Session 2 Problems

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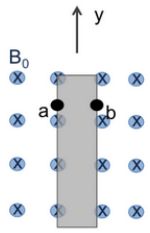
11/8

1 The Hall Effect

1.1 Moving Slab

A metal strip of length L and width w and thickness t is moves with a velocity v through a magnetic field B_0 into the page as shown below. If a potential difference of V_0 is measured between points a and b across the strip, calculate the speed v of the strip.



Source: modified from Halliday, Chapter 34-4, problem 39

1.2 Stationary Slab

Suppose we have a rectangular block with length l, width d, and height h in the x,y, and z directions respectively. A current $\vec{I} = I\hat{x}$ flows through it. There is an external magnetic field $\vec{B} = B\hat{y}$.

(a) Derive the Hall voltage V_H for this setup.

(b) Find an expression for the Hall constant

$$K_H = \frac{V_H}{BI}$$

in terms of the charge carrier concentration n.

(c) Using these results, how can you determine the sign and density of charge carriers in a material?

Source: Dan and Vetri

2 Midterm Example Problems

2.1 Spinning Rods

A uniformly charged rod of length L and charge Q spins at angular velocity ω about an axis through the center of the rod perpendicular to the length.

(a) Calculate the magnetic moment.

(b) If a uniform magnetic field $\vec{B} = B_0\hat{z}$ is present, what is the torque on and potential energy of this rod.

Source: modified from Packard Final Exam, Spring 2000, question 4

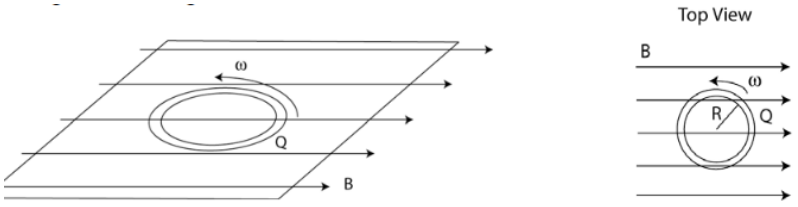
2.2 Non-uniform Field

A rigged square current loop with sides s, current I, and mass m is on a table with coefficient of static friction μ_s. The magnetic field is pointed along the vertical direction, and has magnitude that increases linearly with position: $\vec{B} = B_0\frac{x}{a}\hat{y}$, for a constant a. What is the minimum that μ_s can be if the loop does not move?

Source: Speliotopoulos Final Exam, Fall 2012, question 4

2.3 Levitating Rings?

A ring of radius R, charge Q and mass M is spinning around its symmetry axis. The ring sits on a horizontal frictionless surface. A uniform external magnetic field of strength B is parallel to the plane of the ring. Find the angular velocity ω at which there is zero normal force between one edge of the ring and the surface.



Source: Packard Final Exam, Fall 2004, question 1