Week 12, Session 1 Problems

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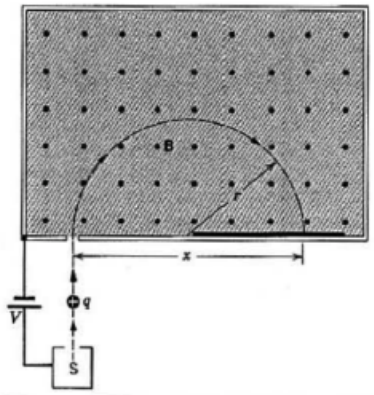
11/6

1 Charges and Magnetic Fields

1.1 Mass Spectrometer

An ion of mass m and charge $+q$ is produces at rest in source S and accelerated across a potential difference V_0 and enters a magnetic field B as shown below. The ion moves in a semicircular path and strikes a plate at a distance x from the entrance slit. show that the mass of the ion can be found by the following equation:

$$m = \frac{B^2 q}{8V_0} x^2 \tag{1}$$

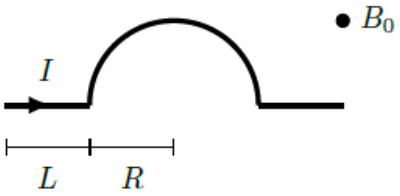


(Source: modified from Halliday, Chapter 34-4, problem 22)

1.2 Forces on Bent Wires

Find the net magnetic force on the whole wire of current I which consists of two straight segments of length L and a half circular segment of radius R as shown below. The magnetic field is constant and in the $\hat{z}$ direction.

(Source: Dan Parker and Vetri Velan)

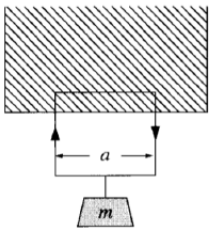


1.3 Magnetic Suspension Magic

A rectangular loop of wire, supporting a mass m, hangs vertically with one end in a uniform magnetic field $\vec{B}$, which points into the page in the shaded region of the figure.

(a) For what current I in the loop would the magnetic force upwards exactly balance gravity downwards?

(b) Now suppose we increase the current. Then the magnetic force up exceeds gravity and the weight is lifted. But *magnetic fields do no work*, so how does this happen? Clearly, *something* must be doing work on the mass — what is it?



Source: Griffiths EM, Example 5.3

1.4 Non-Uniform Fields

Suppose we have a bent wire that starts at $(x, y, z) = (0, 0, L/2)$, goes straight to the origin and then goes straight out to $(x, y, z) = \frac{1}{\sqrt{2}}(L/2, L/2, 0)$. If this wire carries current I in that specified direction and there is a magnetic field $\vec{B} = B_0(x\hat{x} + sin(\frac{4\sqrt{2}\pi}{L}y)\hat{y} + z^2\hat{z})$, what is the net force on the wire?