Concepts of Physics
Lab 3: Moving Charges

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Activity 1: Deflecting electrons

A moving charged particle will feel a force in an electric field, and it will feel a force in a magnetic field. In this experiment you will observe both of these effects. The beam of electrons which comprise the moving charges will be visible because they will strike a screen that glows when struck. You will control the speed of the electrons by controlling the accelerating voltage, V_a, which speeds them up. You will control the electric field E by controlling another voltage, V_d, the deflecting voltage. The magnetic field B will be created by two coils of wire with a current I in them—you will control I.

Play with the controls, and see how applying both electric and magnetic fields deflects moving charges, in different ways.

To hand in for activity 1

Your observations: how does the electron beam deflect (in what direction, in a tighter or less tight curve) as you change the voltages and currents you control?

Activity 2: Charge to mass ratio

It is possible to set up an electric field and magetic field in your apparatus in such a way that the effects of both cancel each other out. We then can then figure out q/m, the charge to mass ratio of the electron.

To do this, say you ask for the help of a physics senior who is supposed to know how to calculate such things. She works for a bit, and presents you with an equation:

$$\frac{q}{m} = \frac{V_d^2 R^2}{2kd^2 V_a N^2 I^2}$$

She then explains that

- V_d: The deflecting voltage you set,
- R: The radius of the coils generating the magnetic field,
- k: A constant depending on the geometry, which in this case she guesses is about $k = 9.0 \times 10^{-7}$ N/A^2
- d: The distance V_d is applied across,
- V_a: The accelerating voltage you set,
- N: The number of coils; $N = 320$.
- I: The current you set through the coils.

Adjust everything so that the path of the electron is a straight line, and measure and write down values for V_d, V_a, d, R, and I. Do this for at least two different sets of values—more if you have time.

Using these data, calculate an experimental value of q/m for an electron for two or more trials, and average those values for a final experimental result.

Then, using accepted values for the electron charge and mass,

$$q = 1.60 \times 10^{-19} \text{ C}$$

$$m = 9.11 \times 10^{-31} \text{ kg}$$

calculate the accepted value of the ratio q/m for an electron.

To hand in for activity 2

All measured values for each trial, experimental q/m for each trial, your final result for experimental q/m, the accepted value of q/m, and comparison with the accepted value.

Comment on how far off the physics senior's prediction was. What do you think might be the biggest problem with it?