ELECTRON CHARGE-TO-MASS RATIO

We use a Helmholz coil to bend a beam of electrons into a circular path, The electron's charge-to-mass ratio is proportional to inverse square radius of curvature of the beam.- a profound measurement in days when the electrons's charge and mass were not well understood!

$$\frac{e}{m} = \frac{2V_{acc}}{B^2 r^2} \qquad (1)$$

V_{acc} is the accelerating voltage, B is the magnetic field intensity in Tesla, and r is the beam radius in meters.

Apparatus:

1) We must first obtain the central value of the magnetic field intensity in the Helmholtz coil, figure-1. Using the gaussmeter, a series of measurements were recorded of the of the Helmholtz coil B-field vs current I_B , see table -1.

You should enter these values in a spreadsheet and plot I(x-axis) vs B(y-axis). Fit the values to a straight line equation to obtain a parametric equation of $\boldsymbol{B(I) = a + b\, I_B}$. You will use the equation to find B **in** the coil**.**

FIGURE-1: Helmolz Coils

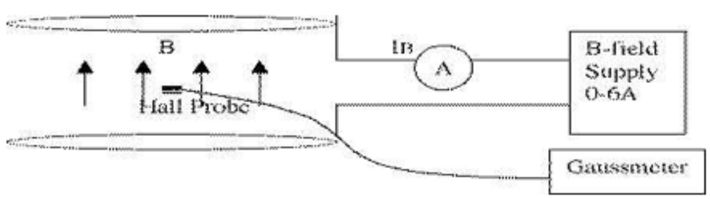

TABLE-1: .B vs I

I_H (A)	1	2	3	4	5	6	
B (gauss)	2.0	3.9	5.8	7.8	9.7	11.6	

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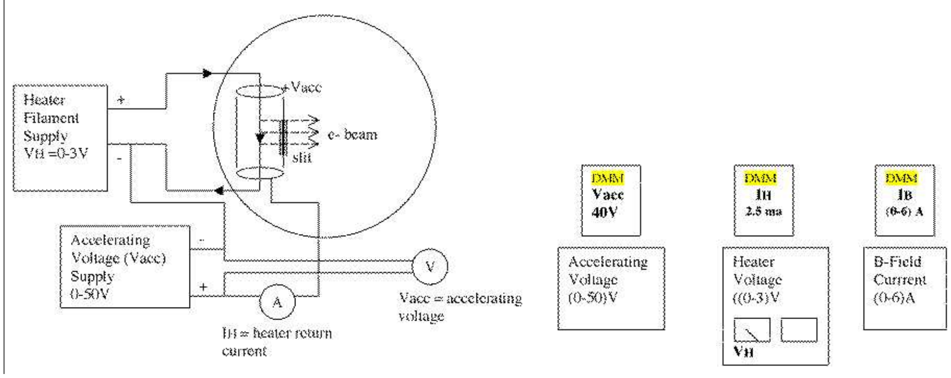
2) The **filament supply** sends current to the **filament wire** which runs down the center of the **accelerating can** inside the e/m tube. The wire will glow as it **thermionically** emits electrons. The electrons are accelerated to the outer **can** and some pass through a narrow slit forming the beam. The can's accelerating voltage (+Vacc) must be positive with respect to the filament to attract electrons. Most elecrons do not pass through the slit but return through the circuit. This **heater return current** $\boldsymbol{I_H}$ is a measure of the beam brightness or intensity. If I_H is too high the **filament could burn out** (like a fuse!). $\boldsymbol{I_H}$ should remain below **3ma** for safe operation.

$Vacc <= (30\text{-}50)$ V	Accelerating Voltage 40V nominal
$V_H = (2.5\text{-}3.0)$V	Heater Voltage
$I_H = (2.5\text{-}3.0)$ma	Heater return current
$I_B = (0\text{-}6)$ A	Current in Helmolz Coil

FIGURE-2: Helhmolz Coils and power supplies.



<u>Startup Sequence</u>

1) First set the accelerating voltage Vacc = 40V. This will act to remove electrons from the heater wire as we turn up the heater current.

2) Set the Helmholz coil current IB to about 1A to initially apply a small magnetic field.

3) Slowly increase the heater voltage V_H to 2V as read from the power supply dial. You should observe the heater wire begin to glow red in the e/m tube (slit). The heater current I_H should increase to about 1.0 ma. Stop and let the circuit burn-in for a while. You may observe the heater return current I_H drop. Increase the heater voltage V_H a bit to compensate, keeping the heater current IH ~ 1.0ma.

4) Wait for the circuits to become stable.

5) Slowly increase the heater voltage V_H to 3V and the heater return current I_H will rise to ~(2-3)ma. You should observe the electron beam emerging from the slit and bending in the B-field. The electrons are exciting Hg atoms in the tube, who emit a soft purple glow. Change the magnetic field current and note the change in circular path.

6) During measurements keep the heater return current I_H at about 2.5 or 3.0 ma. This will allow you to easily see the electron beam.

Measurement

1) With the accelerating voltage Vacc set to 40V (KE e= 40eV!) bend the electrons to each post and record the magnetic field current I_B. The electrons at the outer edge of the beam are the most energetic. These electrons have suffered fewer Hg gas collisions in the tube. Adjust the beam so the outer electrons just hit the posts for best accuracy of measurement. You can wiggle I_B up and down a bit to define a hi-lo range for defining your error ΔI_B .

Post	1	2	3	4	5
I_B(A)					
I_B(A)(wiggle)					
ΔI_B					

Shutdown Sequence

1) First slowly turn down the heater voltage V_H to zero and then OFF **MOST IMPORTANT!**

2) Next the magnetic field current, I_H to zero and then OFF.

3) Finally the accelerating voltage *Vacc* to zero and then OFF.

Short Analysis

1) Calculate the e/m ration for each reading in Table-2. You will need to find $B(I_B)$.

2) Average the e/m for each post from the two readings and take half the difference for the error. Tabulate your answers like below.

3) Plot the e/m ratio (with error bars) vs post number. If this is flat then you may average all the e.m values in table-3 for your final answer with standard deviation as error. If the e/m values are not consistent at each post use the value at the inner post and discuss the problem. The variation over the 5 posts can be used to estimate a systematic error.

4) How **accurate** is your measurement? How well does your measurement agree with the accepted value (% difference)?

5) Be sure to discuss statistical and systematic errors in your short report.