E/M Ratio Experiment

Intro:
- We are to measure the charge to mass ratio of the electron.
- Because electrons have charge, we know they will be affected by a magnetic field.
- Since we know the potential, we know the potential V is given by $V = \frac{N M e I (\pi/5)^{1/2}}{a}$.
- We should see the electron beam turn into a circle.

Procedure:
- First we set up the Helmholtz apparatus with: Hetero: 6.3 V
  - Electrode voltage 150–300 VDC
  - Helmholtz coil voltage 6.9 VDC
  - Helmholtz coil current 0.2 A
- We let the beam warm up and then got
  - what looks like this.

- We started our measurements at about 300 V.
- For our electrode voltage
  - We had Helmholtz coil voltage at 9 V and current 0.1 A
- We measured the ratio at several different values of electrode voltage between 300V–175 V to get a wide range of voltages to see better E/M ratio.
- In order to measure the ratio we looked for where the electron beam edges were the same value on both sides (so it is in the center of the ruler) and measured that value as well as the reflected value in the ruler by increasing these two very small.

- We get the true reading because the red and blue lines on opposite distance monitor.
1. We start and have \( F = ma \) and \( a = \frac{v^2}{r} \) and \( F = evB \). First I substitute ac for a in \( F = ma \) to get \( F = m\left(\frac{v^2}{r}\right) \). I then substituted \( F \) with \( evB \) to get \( evB = m\left(\frac{v^2}{r}\right) \) when I divide both sides by \( v \) I get \( eB = m\frac{v}{r} \) then I divided both sides by \( m \) and by \( B \) to get the final equation \( \frac{e}{m} = \frac{v}{Br} \).

2. We start with the equations \( \frac{e}{m} = \frac{v}{Br} \) and \( ev = \frac{1}{2} mv^2 \). In order to substitute the later equation into the first we must get it in terms of velocity. First we divide both sides by \( \frac{1}{2} \) (multiply by 2). Then we divide by \( m \) and take the square root. The resulting equation is \( v = \sqrt{\frac{2ev}{m}} \) when we sub this into our first equation we get \( \frac{e}{m} = \frac{\sqrt{2ev}}{Br} \). I first divided each side by \( Br \) to get \( \left(\frac{e}{m}\right) B r = \frac{\sqrt{2ev}}{m} \). To get rid of the square root I squared both sides to get \( \left(\frac{e}{m}\right)^2 B^2 r^2 = \frac{2ev}{m} \). I then multiplied both sides by \( m/e \) to get the desired equation of \( \left(\frac{e}{m}\right) B^2 r^2 = 2V \).

3. Because our electron ring is closer than the ruler behind it the object has a parallax. So when we measure our radius the values are actually larger than they should be. To fix this we use the fact that ruler is a mirror. From optics we know that the real image and imaginary image appear to be the same distance apart from the mirror but in opposite directions. Because of this we measure the real and imaginary radius and average them. The resulting radius is then the true radius.

4. In order to get \( e/m \) as the slope we need to use \( \left(\frac{e}{m}\right) B^2 r^2 = 2V \). If we follow the form \( y = mx + b \) and compare it to our equation we know that \( y \) for us is \( 2V \) and since we want \( m \) (our slope) to be \( e/m \) then \( x \) for us is \( B^2 r^2 \).