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 $V$ we know our field strength $B$ is given by $B = \frac{N I_0}{a} (4/5)^{1/2}$
- We should see the electron beam turn into a circle.

Procedure:
- First we set up the Helmholtz apparatus with: Heater 6.3 V
  (V) Electric voltage 150-300 VDC
  Helmholtz coil voltage 6.9 VDC
  (I) Helmholtz coil current 0.2 A
- We let the beam warm up and then get what looks like this.

- We started our measurements at about 300 V
  - We had Helmholtz coil voltage at 9 V and current @ 18 A
- For our Electrode Voltage
  - We measured the reading at several different values
    of electrode voltage between 300V-175 V to get a wide range of voltages to set a 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 averaging those two only we get the true reflection because the red and mixing on a line with distance from the ruler.

$N = \text{number of turns of coils}$

$I = \text{Current of coils (charge)}$

$a = \text{Radius of coils}$

$M_0 = \text{Magnetic Permeability}$

$\frac{1.26 \times 10^{-6}}{\text{T.m/A}}$

$15 \text{cm}$
1. We start and have $F = ma$ and $a_v = \frac{v^2}{r}$ 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 $evB = m \frac{v^2}{r}$ 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 $\frac{v}{2}$ (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 $\frac{e}{m} = \sqrt{\frac{2ev}{Br}}$. I first divided each side by Br to get $\left( \frac{e}{m} \right) Br = \sqrt{\frac{2ev}{m}}$. 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 $B^2 r^2$. 

<table>
<thead>
<tr>
<th>V</th>
<th>Real radius (cm)</th>
<th>6 radius (cm)</th>
<th>Actual radius (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>38.2 V</td>
<td>5.8 cm</td>
<td>4.9 cm</td>
<td>5.35 cm</td>
</tr>
<tr>
<td>27.5 V</td>
<td>5.7 cm</td>
<td>4.6 cm</td>
<td>5.15 cm</td>
</tr>
<tr>
<td>250 V</td>
<td>6.5 cm</td>
<td>4.3 cm</td>
<td>4.9 cm</td>
</tr>
<tr>
<td>226 V</td>
<td>5.3 cm</td>
<td>4.1 cm</td>
<td>4.7 cm</td>
</tr>
<tr>
<td>200 V</td>
<td>5.2 cm</td>
<td>4.0 cm</td>
<td>4.6 cm</td>
</tr>
<tr>
<td>176 V</td>
<td>5.1 cm</td>
<td>3.9 cm</td>
<td>4.5 cm</td>
</tr>
<tr>
<td>280 V</td>
<td>6.0 cm</td>
<td>4.6 cm</td>
<td>5.3 cm</td>
</tr>
<tr>
<td>270 V</td>
<td>5.5 cm</td>
<td>4.1 cm</td>
<td>4.8 cm</td>
</tr>
<tr>
<td>210 V</td>
<td>5.3 cm</td>
<td>4.0 cm</td>
<td>4.6 cm</td>
</tr>
</tbody>
</table>
**Result:**

<table>
<thead>
<tr>
<th>$\eta/m$</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.928 x $10^{-4}$</td>
<td>5.26 x 0.022</td>
</tr>
<tr>
<td>1.633 x $10^{-4}$</td>
<td>5.32 x 0.020</td>
</tr>
<tr>
<td>1.698 x $10^{-4}$</td>
<td>5.30 x 0.021</td>
</tr>
<tr>
<td>1.905 x $10^{-4}$</td>
<td>5.00 x 0.017</td>
</tr>
<tr>
<td>1.685 x $10^{-4}$</td>
<td>5.05 x 0.016</td>
</tr>
<tr>
<td>1.688 x $10^{-4}$</td>
<td>5.28 x 0.010</td>
</tr>
<tr>
<td>1.590 x $10^{-4}$</td>
<td>5.05 x 0.014</td>
</tr>
<tr>
<td>1.948 x $10^{-4}$</td>
<td>5.00 x 0.016</td>
</tr>
<tr>
<td>1.423 x $10^{-4}$</td>
<td>5.25 x 0.015</td>
</tr>
</tbody>
</table>

**Actual Value:**

$1.95 \times 10^{-4} \, \text{C/kg}$

**Graph:**

Write up as well as example picture.

**Discussion:**

More of my data fell within the error. However, the results are good. My $\eta/m$ ratio is actually quite close to that of the actual value. Much of the error comes from the error of measuring the body of the electron beam. It is very hard to get a good value.

**Scratch Work:**

\[
\sigma_{\eta/m} = \sqrt{\left(\frac{d\eta}{d\eta}ight)^2 + \left(\frac{d\eta}{d\eta}ight)^2}
\]

\[
\sigma_{\eta/m} = \sqrt{\left(\frac{\partial \eta}{\partial m}\right)^2 + \left(\frac{\partial \eta}{\partial n}\right)^2}
\]

\[
\sigma_{\eta/m} = \sqrt{\left(\frac{-4V}{\eta^2} \cdot \sigma_{\eta}^2 + \left(\frac{\partial \eta}{\partial n}\right)^2 \cdot \sigma_{\eta}^2\right)}
\]

\[
\eta = \frac{T \cdot m \cdot S}{A} \Rightarrow \frac{T \cdot m \cdot S}{A} \cdot \frac{1}{k} = \frac{T \cdot V}{k}
\]

\[
\eta = \frac{V}{T \cdot m \cdot S} = \frac{k \cdot S^2}{A} \Rightarrow \frac{k \cdot S^2}{A} \cdot \frac{1}{k} = \frac{A \cdot S}{k}
\]

\[
A \cdot S = c \Rightarrow \frac{c}{k} = \\ \sqrt{V}
\]