e/m

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This experiment measures the charge to mass ratio of the electron. The mass ratio is determine by measuring the radius of the circle made by a beam of electrons ecposed to an electric and magnetic field.

1. INTRODUCTION

A magnetic field $\vec{B}$ produced a force $\vec{F}$ on a particle of charge e moving at velocity $\vec{v}$ that is given by the following equation:

$$\vec{F} = e\vec{v} \times \vec{B} \tag{1}$$

This force caused the particle to follow a spiral path since the direction is always perpendicular to the velocity. The radius of the circle r can be determined by the equilibrium of the magnetic and centripetal forces:

$$evB = \frac{mv^2}{r} \tag{2}$$

$$r = \frac{mv}{eB} \tag{3}$$

m is the mass of the particle. The last equation we need to arrive and expression for $\frac{e}{m}$ is the kenetic energy a charged particle aquires when falling through a potential difference V:

$$eV = \frac{1}{2}mv^2 \tag{4}$$

Solving this for v^2 and substituting into equation 3 we arrive at

$$\frac{e}{m} = \frac{2V}{B^2r^2} \tag{5}$$

2. EXPERIMENTAL SETUP AND PROCEDURES

Equation 5 contains three independent variables. Three dataset sets were collected where one parameter was held constant and the other two were varied. The resulting data was then plotted sothat the slope of the line could be used to find the value of $\frac{e}{m}$.

For the first trial, the accelerating voltage was held at 146.6 ± 0.1 V. The current to the helmholtz coil were then varied and the resulting current and radius were recorded (Fig. 2). The second data set held the helmholtz coil current at 1.6 ± 0.1 A and the and the accelerating voltage was varied. The results voltage and

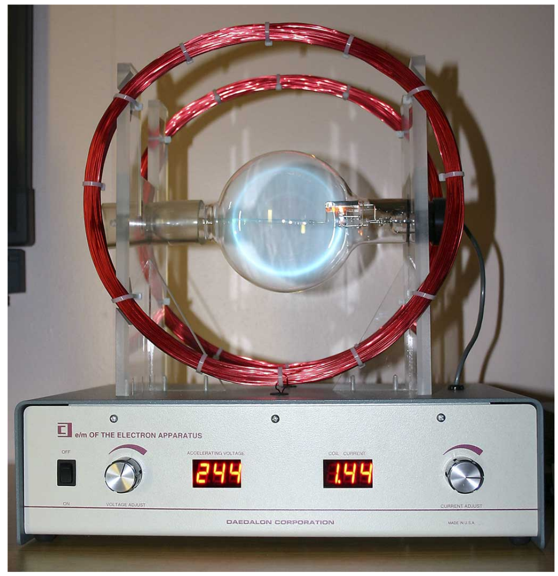

FIG. 1: $\frac{e}{m}$ appatatus used in this experiment

radius were recorded (Fig. 3). The was repeated a third time holding the radius constant at 0.06 ± 0.005 m. The coil current and accelerating voltage were varied and recorded (Fig. 4).

3. RESULTS AND DISCUSSION

Converting the slopes found by plotting the data in R to values of $\frac{e}{m}$ results in the values in table I.

TABLE I: Results

e/m	% Difference
$1.67 \times 10^{1}1 \pm 2 \times 10^9$	5.0
$1.69 \times 10^{1}1 \pm 1 \times 10^9$	3.8
$1.69 \times 10^{1}1 \pm 1 \times 10^9$	3.8

The data agrees with the accepted value of 1.761011 (C/kg) to with in 5.0%. The percent differences for all trials are between 3.8% and 5.0%.

4. CONCLUSION

This experiement was a great experience is working with electromagnetism to find the electron charge to mass ration. The data was consistent for each method of calculating $\frac{e}{m}$ and fits the expected values very well.

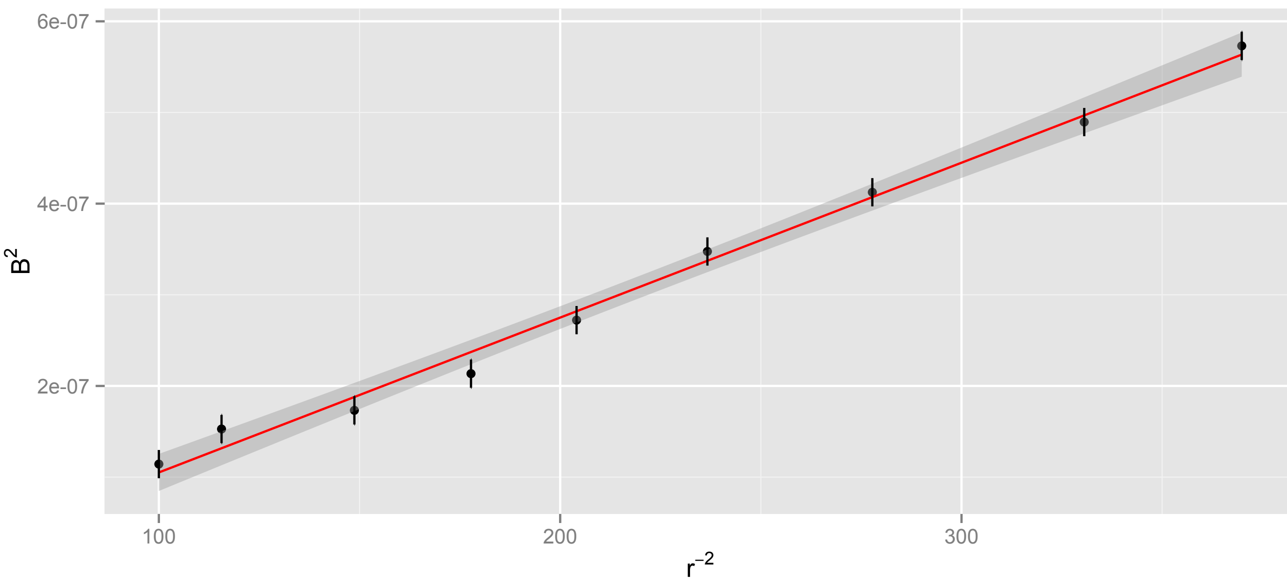

FIG. 2: Graph of B^2 vs $\frac{1}{r^2}$. Slope: $1.70 \times 10^{-09} \pm 6 \times 10^{-11}$ $R^2 = 0.990$. Accelerating voltage held at 146.6 V

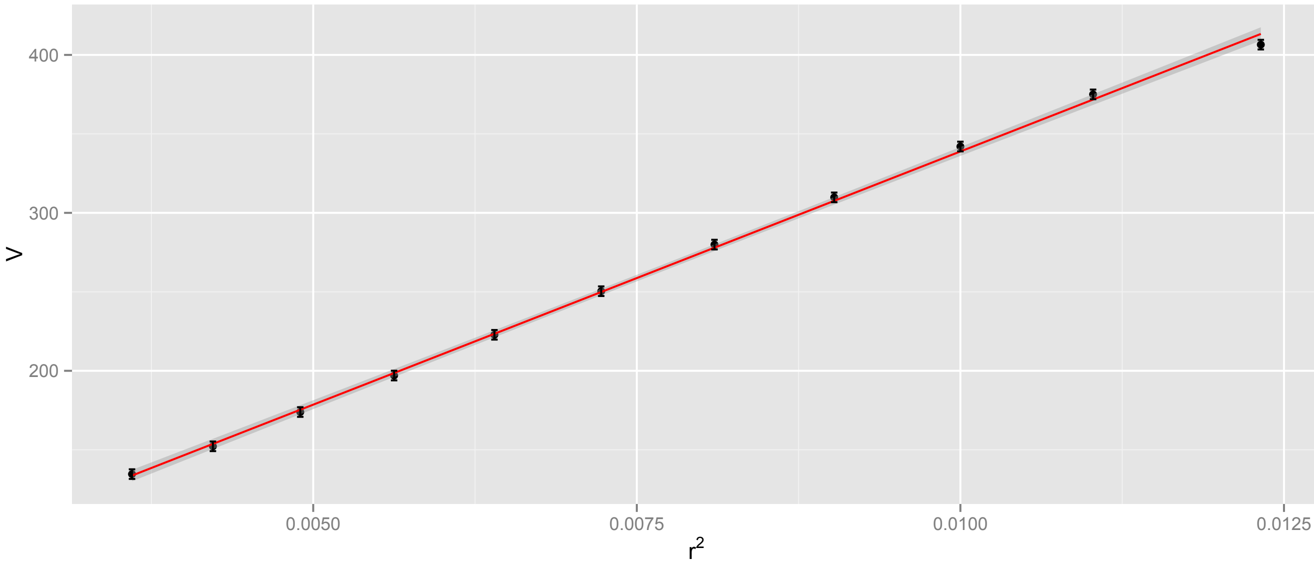

FIG. 3: Graph of V vs r^2. Slope: $3.21 \times 10^4 \pm 3 \times 10^2$ $R^2 = 0.999$. Coil Current held at 1.60 A

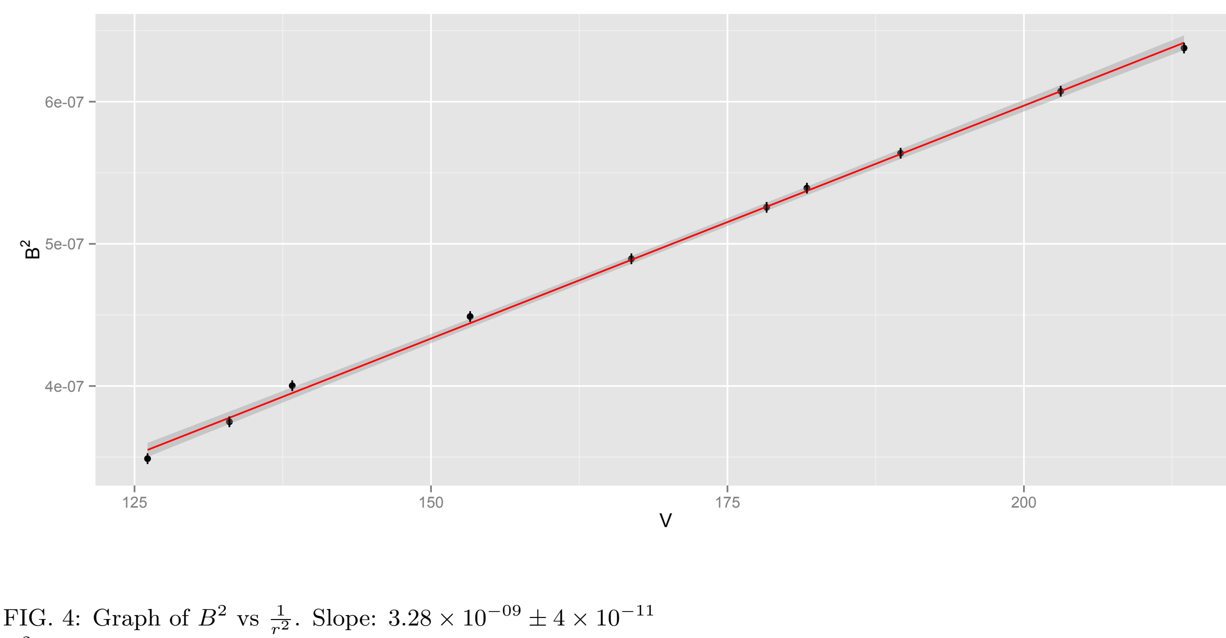

FIG. 4: Graph of B^2 vs $\frac{1}{r^2}$. Slope: $3.28 \times 10^{-09} \pm 4 \times 10^{-11}$ $R^2 = 0.999$. Radius held at 0.06 m