Mass of Electron Apparatus (E/M)
PSSC

AP2120-001   Mass of Electron

Description:

In the early days of Radio, the "Magic Eye Tube" was a very effective method of indicating that the radio station was properly tuned in. The 'fan shaped' illumination became narrower as the tuning improved and the tuning knob was adjusted to get the narrowest 'fan'. This same tube is used today, not for radio, but for viewing the path of an electron beam. One of these special tubes is mounted on a plastic base fitted with a valve socket and with cables for connection to a power source. When the tube's heater and anode are connected, the electron beam flows from the centre to the outside across a fluorescent surface that glows green where the electrons are passing. The shape of the glow is 'fan' shaped and it is formed from the central cathode to the circular anode surrounding it.

If a magnetic field is created around the tube, the fan shaped beam is curved due to the effect of the magnetic field applying a deflecting force to the electrons that form the beam. In this experiment, the magnetic field is formed by a normal Air Cored Solenoid which is placed over the tube so that the electron beam is at the mid point of the solenoid. Both the current through the solenoid and the number of turns of the solenoid are known, thus the field strength at the mid point of the solenoid may be calculated. The degree of curvature in the electron beam is measured at different field strengths and, by calculating and using the laws of dynamics, the mass of an electron can be found with a fair degree of accuracy.

Connections to the Electron Tube Unit:

- Heater supply:
  12V.AC or DC at 1 amp.

- Anode to Cathode:
  up to 250V.DC at 10mA.

Air Cored Solenoid: (not part of the 'Mass of Electron' kit). Cat: EM0090-001

- Max. current allowable in winding: 5 amp.
- Typ. coil current for 'Mass of Electron': 2 amp.

- The number of turns in the solenoid is marked on the unit.

Length: 82mm	Width: 115mm	Height: 105mm	Weight: 130g

Power Supplies:

Three separate power supplies can be used for the 12V.AC or DC tube heater circuit, the smooth (filtered) 250V.DC. tube Anode voltage and 0 - 2 amps of smooth DC current required to operate the solenoid that fits around the tube.   However, IEC manufactures a special Power Supply (LB2622-002) that provides the two voltages for the tube together with a Constant Current power source for the Air Cored Solenoid that provides the required magnetic field.

Preparation For An Experiment:

Connect a 12 V.AC. or DC. Power source to the heater terminals of the electron tube and connect a high voltage DC. power supply to the Anode/Cathode terminals. As the high voltage is increased to about 200 to 250 V. DC. the fan shaped pattern of the electron flow, visible through the end of the tube, will be seen to have straight sides.

Place the Air Cored Solenoid over the tube and look down into the solenoid to view the end of the tube. Connect the terminals of the solenoid to a smooth low voltage DC. power supply via a DC. ammeter, or better, to an adjustable constant current power supply and adjust the current gradually to a maximum of about 2 amps.

NOTE: The physical size of the system is designed so that the fan pattern is very close to half way up the Air Cored Solenoid at the mid point of the magnetic field.

As the current increases through the coil and the magnetic field rises in strength, the fan pattern of the electron flow will be seen to curve around as the electrons are deflected from their straight line path to the anode.

Monitor the Anode voltage and the solenoid current and adjust either or both of them until the curve of the sides of the fan pattern matches the curve of an object (say a pencil or a small coin glued to the end of a pencil) which is inserted vertically down into the mouth of the solenoid so that it rests on the upper face of the tube.

When the curvature closely matches the curve of the object, carefully measure the voltage applied to the anode of the tube and the current through the coil. Remove the circular object and measure the radius of curvature of the object. This dimension will closely approximate the radius of curvature of the electron flow.

The curvature alters with the acceleration potential of the electrons (Anode voltage) and the field strength at the centre of the solenoid (solenoid current). Remember that as the coil will increase its resistance due to an increase in temperature and a fall in current will occur. If you are not using a 'Constant Current' power supply, a normal power supply will need to be slightly adjusted from time to time to maintain a steady current through the coil.

Refer to physics text books for the formulae relating to the calculations for the strength of the magnetic field and the velocity of the electrons.   From this information you can calculate the approximate mass of a single electron.

View Of The Electron Flow Through The 'Magic Eye' Tube
With And Without A Magnetic Field Applied.
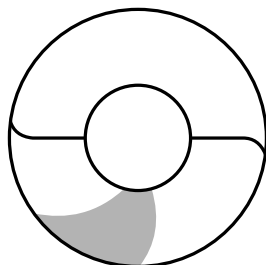
Magnetic field applied
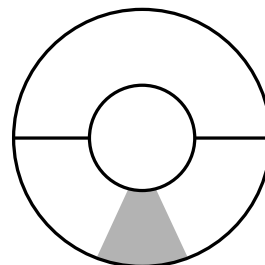
No magnetic field

Designed and manufactured in Australia