M.Sc. PHYSICS LAB MANUAL
2nd & 3rd Semester

MIDNAPORE CITY COLLEGE

MCC

ESTD. - 2017

Prepared By
Dept. of Pure & Applied Science
Physics

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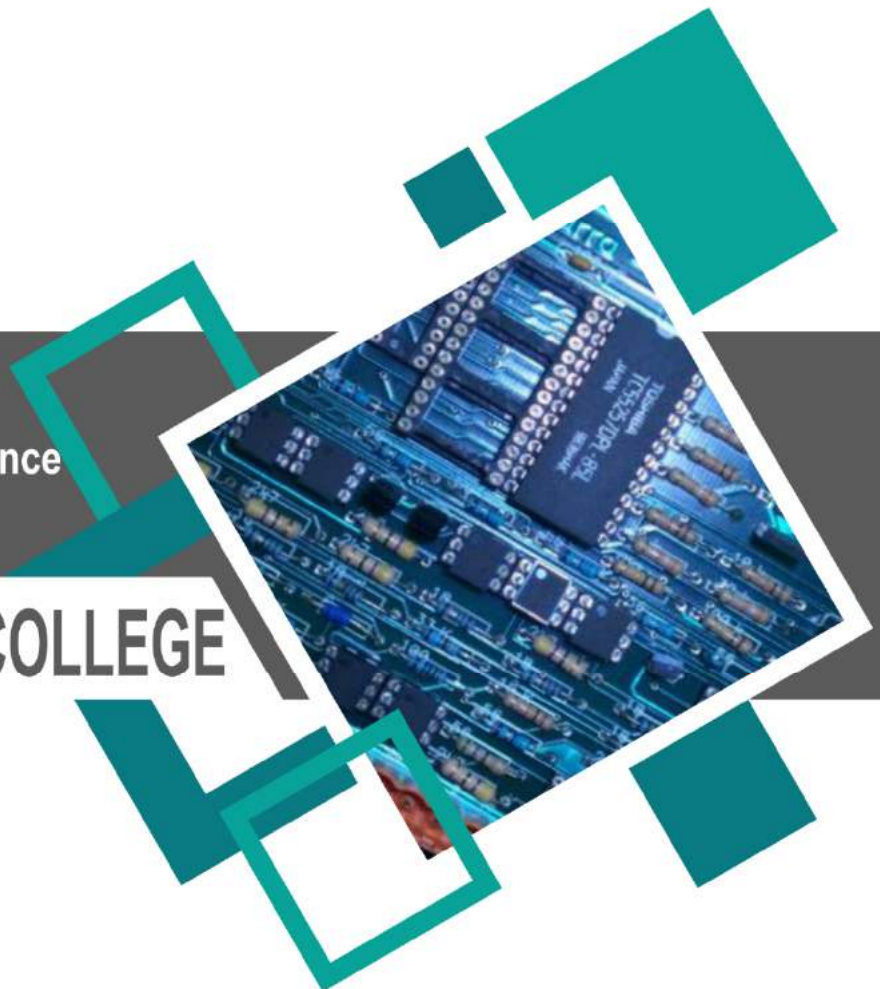
# Course No: PHS 296: Advance Practical-I

Credit: 4, Marks: 50

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Experiment-1

AIM: To study the linearisation LED Characteristics and finding out the quantum efficiency:

Theory and Circuit diagram:

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device. Here we study the variation of LED current and power with LED voltage.
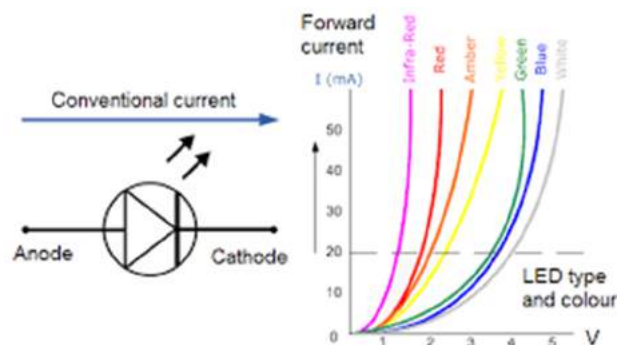
Fig 1: LED symbol and I-V characteristics
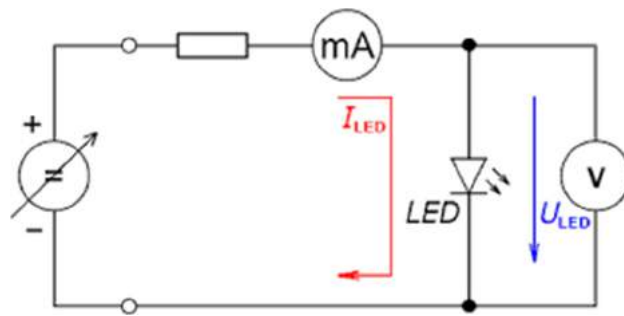
Fig 2: Circuit diagram to study LED characteristics

Experimental Data

Table-1

Voltage drop against LED in Volt	Current in mA	L in Lux	Electrical power	Cut in point

Repeat the same for at least three different colors of LED and the following curves to be drawn

1. LED Voltage vs Current

2. LED Voltage vs Lux

3.LED Power vs LuxTable-2

Precautions and Discussions

1. The circuit should be implemented properly.

2. Before connect the LED to the circuit check the LED.

3. Use a proper resistance to save the LED.

4. Before connect the dc power supply and voltmeter and ammeter check this properly and connect all the wires carefully.

5. After completing the experiment power off all the meters and sources.

Experiment-2

AIM: Measurement of Hall coefficient of a given sample and calculation of its concentration:

Theory and circuit diagram: If an electric current flows through a semiconductor in a magnetic field, the magnetic field exerts a transverse force on the moving charge carriers which tends to push them to one side of the conductor. This is most evident in a thin flat conductor as illustrated. A buildup of charge at the sides of the conductors will balance this magnetic influence, producing a measurable voltage between the two sides of the conductor. The presence of this measurable transverse voltage is called the Hall Effect after E. H. Hall who discovered it in 1879.

Hall voltage $V_H = R_H \times I \times H/y$……………...(1)

Where, R_H is the Hall coefficient and can be written as

$R_H = (V_H \times y)/(I \times H)$………………………...(2)

Now if n be the carrier concentration of the specimen then

$R_H = 1/ne$ ……………………………..(3)

Using this formula we can easily calculate the value of carrier concentration.

(VDS) is high enough to causes the JFET's resistive channel to break down and pass uncontrolled maximum current.
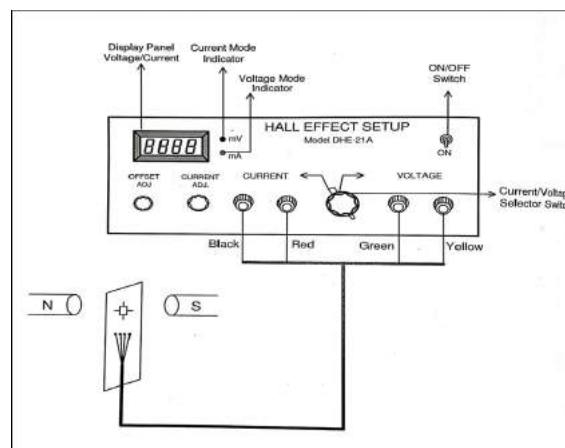

Fig 3: Panel diagram of Hall Effect setup

Experimental results

Data for current vs magnetic field curve

Table I

Direct current in Amp	Magnetic field in Gauss

Table II

Reverse current in Amp	Magnetic field in Gauss

Table III

Data for current vs Hall voltage for a fixed magnetic field:

Direct current through electromagnet Current in mA=....		Reverse current through electromagnet Current in mA=....		Average Hall voltage
Hall voltage for direct current(through the sample) V_H in mV	Hall voltage for reverse current(through the sample) V_H in mV	Hall voltage for direct current(through the sample) V_H in mV	Hall voltage for reverse current(through the sample) V_H in mV	

Calculation of slope of the current vs Hall voltage curves for different magnetic fields

Mag. Field	Change in Hall Voltage ΔV_H in mV	Change in current ΔI in mA	Slope

Calculation of Hall coefficient:

Width of the sample=0.05 mm

Mag. Field	Slope of I vs V_H curve	Hall coefficient $R_H=(y\times slope)/H$	Avg. R_H	$n=e/R_H$	Avg. Value on n per m^3

Precautions and Discussions

1. Make the circuit connection carefully.

2. Check the sample before place in the magnetic field.

3. Vary the value of magnetic field within the proper range.

4. After completing the experiment power off properly.

Experiment-3

AIM: Measurement of e/m by magnetron valve

Apparatus- Magnetron (diode valve) R. C. A 41 or 42, *E* 1189, standard long axial solenoid in which the diode can be mounted at the centre, Power supply unit consisting of a L.T. supply (for heating the cathode of diode), a supply of about 30V (to supply magnetising current to the Solenoid) and an H.T. supply for the plate of diode, two suitable rheostats , a volt meter, an ammeter, keys and connecting wires.

Theory and Circuit diagram: A magnetron is a diode valve in which the electron can move in a magnetic field as well as in an electrostatic field between the cathode and the anode (or Plate). The diode consists of a cathode in the form of a straight wire and a cylindrical plate co-axial with the cathode. In the absence of any magnetic field the electron normally leaves the cathode along a straight path in a direction perpendicular to the anode due to the electrostatic field between the cathode and the anode. If V is the potential of the anode (plate) with respect to the cathode, the velocity gained by the electron on reaching the plate is given by

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

or $v = \sqrt{\frac{2eV}{m}}$

Where e is the charge on the electron and *m* its mass. A longitudinal magnetic field along the axis of the wire filament (Cathode) is applied by placing the cylindrical diode valve inside a straight solenoid consisting of a large number of layers of thick insulated copper wires able to carry a current of 10-15 amperes. It is long enough to produce a uniform magnetic field along its axis at its middle point. The diode valve can easily slide in or out of the solenoid. When a current is passed through the solenoid the electron experience a force given by-

F=Bev

at right angles to its direction of motion. B is the intensity of the magnetic field at a point on the axis of the solenoid at it s middle. Because of this force the electron is made to move in circular path. If the applied magnetic field is weak, this force will give some curvature to the electron path which is straight in the absence of the field. As the field is increased still further, The electron path is more and more

curved till for a value of the field $= 8$ known as *critical field* the electron just reaches the plate or anode i.e. the electro n just grazes along the anode (or plate). For values of the field above *B,* the path is highly curved and electron does not reach the anode or plate. At this stage the anode or plate current is zero. In other words, as the magnetic field is increased gradually, the anode current remains almost constant but above a particular critical value *B,* the anode current drops suddenly as shown in fig. The cut off is by no means sharp, the curve showing a distinct knee and foot. It is clear that when $B=O$ the electron goes straight from the cathode to anode (Plate). When $B< B_c$ it follows a curve path (Curve b) When $B=B_c$ the electron just grazes along the anode (Curve c). When $B>B_c$ the electron moves in a circular path and misses the anode (Curve d). Suppose r_a is the radius of the cylindrical anode or plate of the diode valve and B_c is the critical magnetic field, then

$$B_c ev = \frac{mv^2}{\frac{r_a}{2}}$$

Measurement of e/m and electronic charge

$$mv = \frac{B_c er_a}{2}$$

But
$$v = \sqrt{2\,eV/m} = \frac{B_c er_a}{2m}$$

$$\frac{e}{m} = \frac{8V}{B_c^2 r_a^2} \quad \text{Ckg}^{-1}$$

If the critical magnetic field is produced by a solenoid of Length *L,* having n turns per meter. If I_c is the current through the solenoid for critical field (i.e. for cut off plate current), then

$$cos\theta = \frac{L/2}{\left[R^2 + \left(\frac{L}{2}\right)^2\right]^{1/2}} = \frac{L/2}{\left[\left(\frac{D}{2}\right)^2 + \left(\frac{L}{2}\right)^2\right]^{1/2}} = \frac{L}{[D^2 + L^2]^{1/2}}$$

R being the average radius of the Solenoid and *D* its corresponding diameter.

Procedure

1. Place the solenoid in the E-W direction. Slide the magnetron tube gently inside the solenoid so that it is at its centre.

2. Draw a diagram showing the scheme of connections. Make necessary connections from the power supply unit as shown in fig.

3. Switch on the L.T. Supply and let the cathode get heated up.

4. Switch on the H.T. supply with the help of the rheostat *Rh,* apply a voltage say 60V to the plate of the diode. The milliammeter will show some deflection indicating the presence of plate current I_p.

5. Now *switch on Solenoid Power supply* and send a current through the solenoid using the *Potentiometer FINE* with the help of this rheostat increase the value of current I_s through the solenoid from zero to such a value that the plate current in the magnetron diode shown a sharp fall. This sharp fall occurs when the magnetic field produced by the solenoid just exceeds the critical value B_c. Record all the values of the solenoid current I_s (in Amp) by increasing it from zero upward in small steps and corresponding value of plate current I_p (in mA).

6. Plot a graph between "Current through the solenoid" I_s taken along *X-axis* and corresponding "diode plate current" I_p taken along *Y-axis.* Draw two tangents to the curve at two points B and *D*.

7. Repeat the experiment for plate voltages 70, 80, 90 and 100 volts respectively. Calculate the value of I_c in each case by plotting a separate graph.

Observation Length of the Solenoid L =m

Number of Turns N=

Number of turns per unit length (Per meter) n = N/L=

Diameter of Solenoid D=........... m

Radius of Solenoid R =.........m

[For a standard solenoid L, N and R is generally given by the makers]

$$cos\theta = \frac{L/2}{\left[R^2 + \left(\frac{L}{2}\right)^2\right]^{1/2}} = \frac{L}{[D^2 + L^2]^{1/2}}$$

S.No	Solenoid current in Amp I_p	Plate current I_p in mA				
		Plate voltage (v$_a$) v$_1$=60V	Plate voltage (v$_a$) v$_2$=70V	Plate voltage (v$_a$) v$_3$=80V	Plate voltage (v$_a$) v$_4$=90V	Plate voltage (v$_a$) v$_5$=100V
1.						
2.						
3.						
4.						
5.						

6.						
7.			15			

Precautions and Discussions

1. Magnetron valve should be placed in the middle of the solenoid with its axis coincident with the axis of the solenoid.
2. At the critical value the current should not be allowed to flow in the solenoid for a long time as it would heat up the wires.
3. The voltage applied to the diode plate should not exceed the maximum permissible value as recommended by the manufacturers.
4. The Current in the filament circuit should remains constant.

AIM: To Study of the characteristics of a GM tube

Apparatus Required: GM Counting System GC601A / GC602A with A.C. main chord, GM Detector (End window) stand (or) G.M Detector/source holder bench (optical bench), GM Detector (in PVC cylindrical enclosure) with connecting cable.

Theory and Circuit diagram:

FIG 4 : TYPICAL G.M. CHARACTERISTICS

FIG 5 : TYPICAL G.M. PULSE OUTPUT SEEN ON AN OSCILLOSCOPE
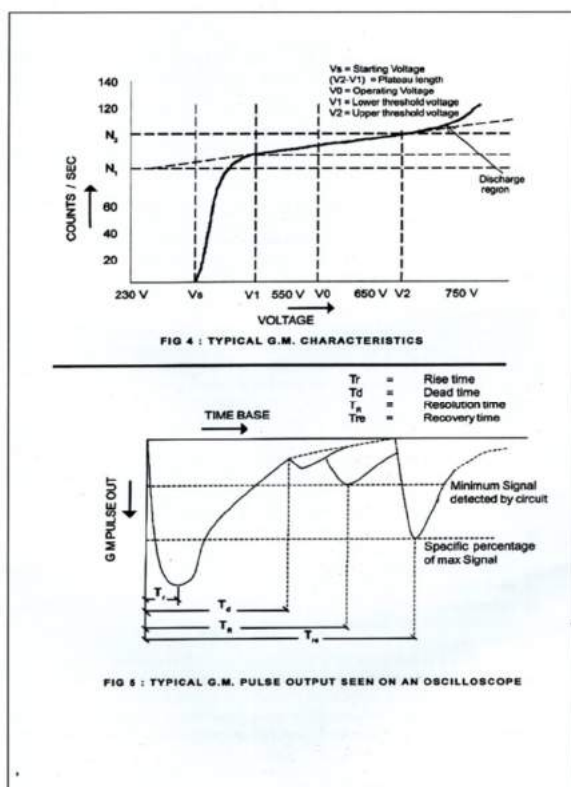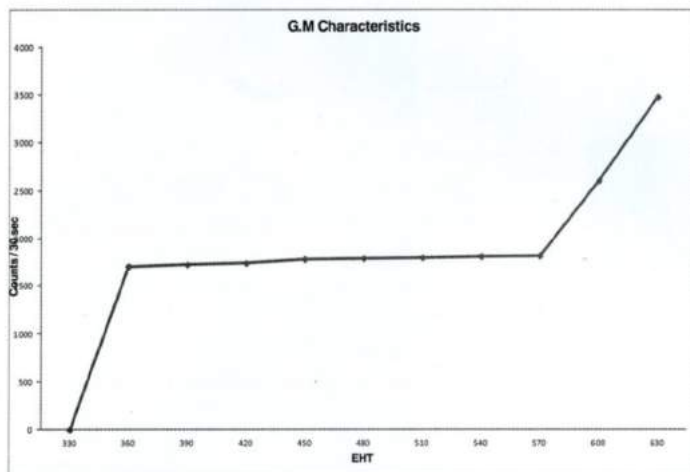
Fig 4: Characteristics of GM tube

Fig. 6 : Plot of counts Vs EHT

Procedure:

1. Make the connection between counting system to GM. Detector by MHV to UHF co- axial cable. Also connect the mains chord from the counting system to 230V A.C. Power .

2. Place a Gamma or Beta source tacing the end window ot the detector, in the source holder of G.M. stand or optical bench at about 2 cms (for Gamma source) or 4 cms (for Beta source) approximately, from the end window of the detector. (For Beta source ensure that countrate is less than 200 CPS at SOOV)

3. Now power up the unit and select menu options to PROGRAM on the keypad of the ECM. Counting System and select 30sec preset time typically (It can be in the range of 30 to 60 sec.) [For all command button Junctions, reter to G.M. Counting System GC601A /GC602A user manual.

4. Now press - "START' button to record the counts and gradually increase the HV by rotating the HV knob till such time, the unit just starts counting. Now, press "STOP" button.
5. Now take a fresh reading at this point (STARTING VOLTAGE) and record the observations in the format as given in Table 1.
6. Also record for each HV setting, corresponding background counts without keeping the source. Continue to take these readings in steps of 30V and for the same preset time, keep observing counts & tabulate the data, with and without source.
7. Initially within 2 to 3 readings, counts will steeply increase and thereafter remain constant with marginal increase (may be 'within 10%). After few readings, one will find a steep increase as one enters the discharge region. Take just one or two readings in this region and reduce the HV bias to 0 volts. It is important to note that operating the QM detector in discharge region for longer time can reduce the life of tube or can result into Dermanent damaae of the detector.

Table - 1 : G.M. Characteristics Data

S.No.	EHT (Volts)	Counts 30 sec N	Background Counts 30 sec N_b	Corrected Counts $N_c=(N-N_b)$ 30 sec
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

ANAYSIS & COMPUTATIONS

Estimate from the tabulated readings

- V_1 = Starting voltage of plateau = 360V
  (Just after rising edge of the plateau)
- V_2 = Upper threshold of the plateau = 570 V
  (Just before the start of discharge region)

  - Plateau length VPL = $V_2 - V_1$ = (570-360) = 210 V
  - Operating voltage $V_o = (V_2 + V_1)/2 = 465$ V
  - The slope of the plateau is given by
    $$\text{Slope (percentage)} = \frac{N2-N1}{N1} X \frac{100}{V2-V1} X100 = \frac{1781-1677}{1677} X \frac{100}{570-360} X100 = 2.95\%$$

Where N1 and N2 are the count rates at the lower and the upper limits of the plateau and V1 and V2 are the corresponding voltages.

**Slope less than 10% is desirable**

CONCLUSIONS

1. From the plateau, it can be noticed that midpoint of the characteristics of the GM tube is defined as operating voltage and is to be used for counting applications. The tube is operated at this voltage when used in Radiation Monitors for measurements.

2. Repeat the experiment with Beta source by keeping the source slightly away from the end window when compared to gamma source and tabulate the data. Calculate slope, plateau length etc. From this, one could notice that with Beta source, the efficiency of the detector increases. Also one can notice that with higher count rates, plateau slope increases.

Experiment-5

Aim: To verify inverse square law using G-M counter

Apparatus: G.M. Counting System GC601 A/ GC602A with A.C. main chord, G.M Detector (End window) stand (or) G.M Detector/source holder bench, G.M. Detector (in PVC cylindrical enclosure), with connecting cable, a gamma source.

Theory and Circuit diagram:
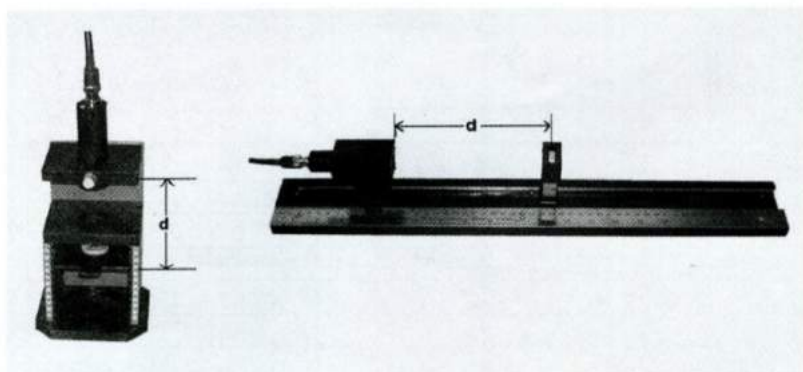
Fig. 7 : Detector, G.M. stand / holder and source arrangement

PROCEDURE

1. Make detector-source arrangement as shown in the (Fig.7) and power up the unit.

2. Without source, make few (about 5 readings) background measurements and take an average of them for a preset time of say 60 sec.

3. Compute Average background counts in 60sec Ba = (b1+b2+b3+b4+b5) / 5.

4. Compute Background rate = Ba/t (t = 60sec)

5. Place a gamma source in the source holder and adjust the distance (d) from the detector end window to be 2 cm away from the centre of the source holder.
6. If you have an End window detector stand, keep the source holder in the 1st slot & raise the end window detector enclosed in a cylindrical shell by unscrewing the captive screw such that you get 2 cm distance from the end window to 1st slot as shown in Fig.7.
7. Set the HV to Operating Voltage (say 500 V), program 'preset time' to 60 sec and record the data counts by pressing 'START' button.

8. Increase the Distance (d) in steps of 0.5cm (5mm) and for each step record the observations and tabulate (table 2) the data as given below till you reach a distance of 8 to 10 cms from the detector face.

9. Subtract the background counts from the recorded counts which results in "corrected counts" (N) in 60sec. From this obtain Net Count Rate (R) per sec.

Table 1 : Data for Inverse Square Law Experiment

S.No.	Distance In cm (d)	Corrected Counts N in 60sec.	Net Count Rate R in 1 sec.	Product Ca::R.d^2	Transformation 1/d^2 in 1/m^2
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

COMPUTATION & ANALYSIS

(a) Compute and tabulate 'Net count rate' (R), 'Distance' (d), product of (C=R.d^2), transformation (1/d^2) etc. as shown in table. (2)

Plot a graph of Net count rate (R) Vs. distance (d) in cm.

If the count rate obeys the inverse square law, it can be easily be shown that the product R.d^2 is a constant. The results of the product (R.d^2 are shown in the table above; allowing for statistical fluctuations, the results obey this law, with a mean value of C "' 904. The observed net count rate as a function of distance is given by

$$R_d = 904/d^2$$

An alternative analysis method involves transforming the data so that the results lie on a straight line. For this purpose "Net Count Rate" (R) Vs. "Reciprocal of the distance square" (1/d^2) are plotted (refer to Fig.9). This will be a straight line passing through the origin (0, 0) as this point corresponds to a source-detector distance of infinity. Gradient can be estimated easily from the "net count rate" (R) corresponding to a value of (1/d^2) of 400 m^2.

In this example: c = 886 which is in agreement with the results of the previous method at 5cm.
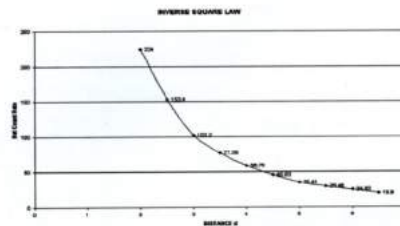
$$C = Rd^2 = 35.42 \times 25 = 886$$

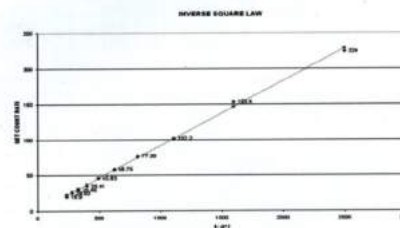Fig (8). Plot of Net Count Rate (R) Vs Distance (d)

Fig (9). Plot of Net Count Rate (R) Vs Inverse Square of Distance (d)

Fig 8: Count rate vs Distance

Precautions and Discussions

1. Make the connection properly.
2. Radio active samples are very dangereous, maintain a minimum distance from the source.
3. After complete the experiment make sure that the power connection is off properly and the source is in the proper box.