

PHYSICS 1040L LAB

LAB 1: INVERSE SQUARE LAW LAB

Objective: The student will verify the inverse square relationship between the distance and intensity of radiation.

Pre-lab Questions:

1. Write a general mathematical expression for an inverse square law. \
2. What are other examples of inverse square laws?

Introduction:

As a source is moved away from the detector, the intensity, or amount of detected radiation, decreases. You may have observed this effect in your daily life. The farther you move away from a friend, the harder it is to hear them. Or the farther you move away from a light source (a street lamp for instance), the harder it is to see.

Also the stars you see at night look like points of light, but you know that is not so. We see our sun every day and it not a point of light, but a sphere. Basically, nature provides many examples (including light, sound, and radiation) that follow an inverse square law.

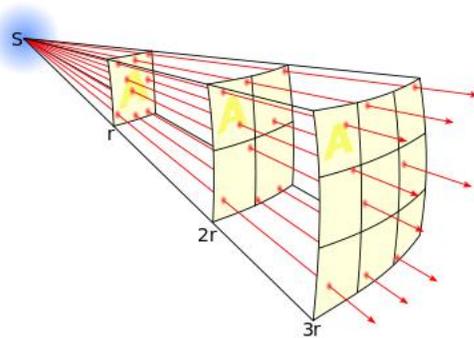


Figure 1 Inverse Square Law: The lines represent the flux emanating from a point source. The total number of flux lines depends on the strength of the source and is constant with increasing distance. A greater density of flux lines (lines per unit area) means a stronger field. The density of flux lines is inversely proportional to the square of the distance from the source because the surface area of a sphere increases with the square of the radius. Thus the strength of the field is inversely proportional to the square of the distance from the source.

Basically what an inverse square law says is that as you double the distance between source and detector, intensity goes down by a factor of four. If you triple the distance, intensity would decrease by a factor of nine. If you quadruple the distance, the intensity would decrease by a factor of 16, and so on and so on. As a result, if you move to a distance d

away from the window of the GM counter, then the intensity of radiation decreases by a factor $1/d^2$.

Equipment:
Set-up for ST-350 Counter with GM Tube and stand (Counter box, power supply – transformer, GM Tube, shelf stand, serial cable, and a source holder for the stand) – shown in Figure 2.

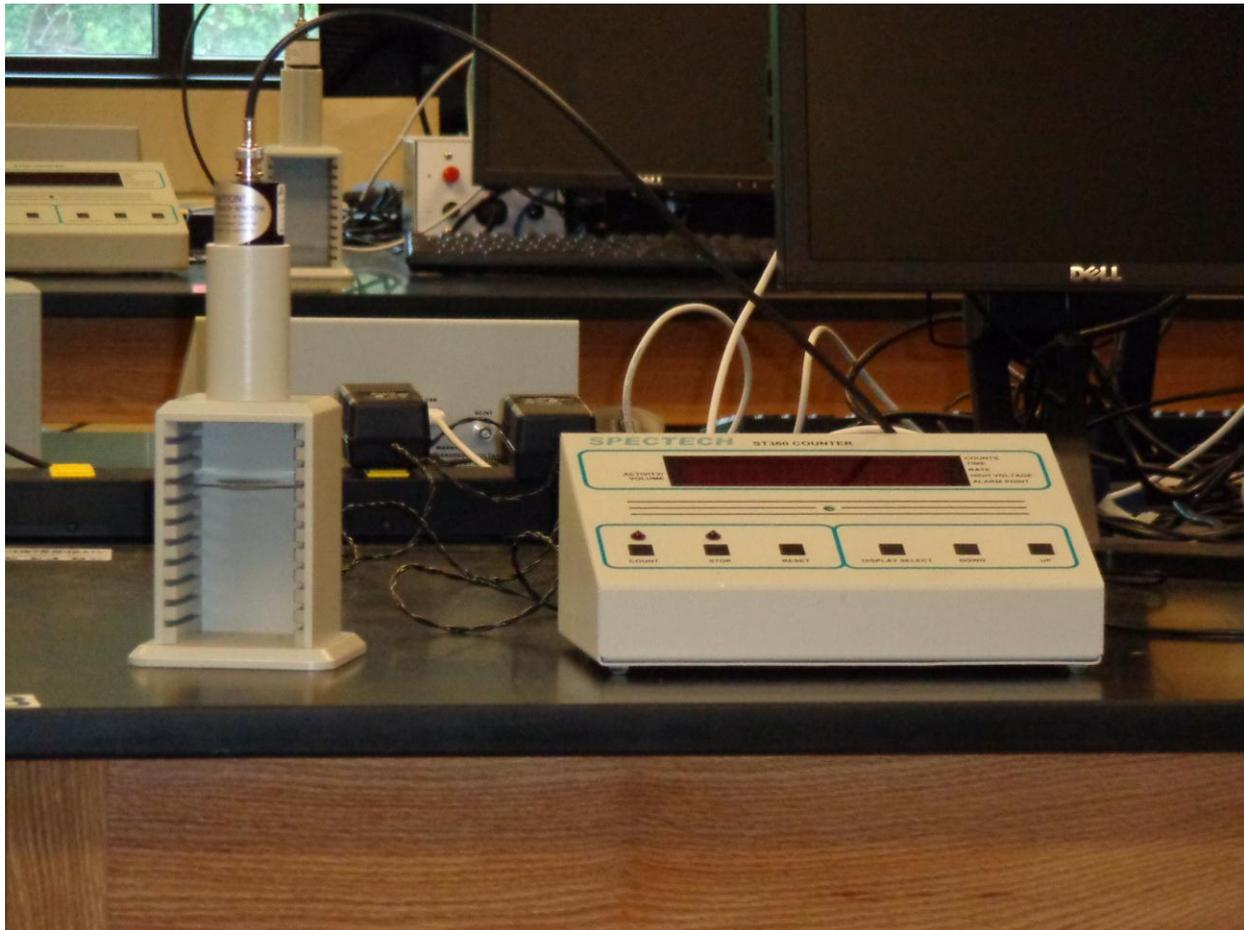


Figure 2 – Setup for ST350 with Geiger Muller tube, stage, sample holder and Scaler.

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Radioactive Source (beta sources – we recommend Tl-204 or Sr-90. One of the green sources shown in Figure 4 – Gamma sources Cs 137, the blue source shown in Figure 4.



Figure 3: Radioactive source and sample carrier.



Figure 4: Different Radioactive sources. Note the Activity, Half Life of each and the radioactive particles emitted.

Procedure:

1. Setup the Geiger Mueller Tube and counter. Set the voltage of the GM tube to its optimal operating voltage, which should be around 840 Volts.
2. First do a run without a radioactive source to determine your background level. From the Preset menu, set Runs to zero and set Preset Time to 300 seconds. Calculate the background count by dividing the total number of counts by five. Record it on your data page. Units are in counts/minute
3. Next, place the radioactive source in the top shelf label side up, and begin taking data. Set the preset time to 60 seconds. In this position, the source is 2 cm from the GM tube's actual detector components. Record the count. Turn the radioactive source label side down.
4. Do another 60 second count. Which one of the 60 second counts is the largest? Keep the source in this position (up or down) through the rest of the experiment.
5. Move the source down one shelf each time and take another run. You should see the data accumulating in the Data window. After all ten shelves have been used, save the data onto disk or USB Flash Drive and record in the data table. Remember that the first run is a background number.

Data Analysis:

1. Using Excel, Vernier's Graphical Analysis, or LoggerPro, record the corrected counts in (Counts/Minute) and distance in (cm) in two columns. Create a calculated column for the distance in (meters). Calculate another column $1/d^2$ ($1/m^2$). **NOTE: Excel is very picky. Make sure the Independent (X) variable, distance, is in the first column of the spreadsheet. Otherwise the data will be plotted backwards on your graph.** For LoggerPro and Graphical Analysis the columns can be labeled, but it is much more easily done. The calculated columns are also easier to work with.
2. Plot your corrected intensity as a function of $1/d^2$. This can be done either using Excel or Vernier's LoggerPro or Graphical Analysis. You should get a straight line.
3. Draw the best linear fit line for your data. Figure out the equation of the line. Note the Regression Coefficient (R^2). The closer the value of R^2 is to +1 or -1, the closer your data is to a linear relationship. The sign of R^2 is the same as that of the slope of the line.
4. Use your graph to determine if the data does indeed obey the inverse square law. If it does, say why it does. If it does not say why it does not. Be specific..

5. **Eliminate the first three data points and plot the data again.** Again note the Regression coefficient (R^2). Does the data obey an inverse square law? Is it better approximation than that shown in the first graph?
6. **Now plot the all the data points (corrected counts vs. the distance in meters).**
7. Use the following equation to fit your data: $Y = AX^n$. What is your value for n ? In theory, if your data behaves as an Inverse Square Law relationship, $n = -2$.
8. **Eliminate the first three data points and plot the data again and fit your data to $Y = AX^n$.** Is it better approximation than that shown in the first graph?
9. Calculate the % error in n for both data sets. Which data set is a better approximation of an Inverse Square Law relationship?
10. Why is there a difference in the values of R^2 and n that you get when you plot the data as outlined above?