Light Experiment: Attenuation

Objective:

This lab shows the mathematical relationship between the attenuation of x-rays through an object and the thickness of the object. This relationship will be used to find the attenuation coefficient, a measure of a material's ability to absorb and scatter x-rays, of transparency film.

Thoughtful Questions:

1. How is a shadow like an x-ray image?

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2. How do you think the shadow of a transparent object will change as the thickness of the object increases?

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Materials:

- Incandescent lamp with 60 watt bulb
- 12" by 12 " piece of aluminum foil
- Transparency sheet cut into 8 equal rectangles
- Light intensity scale
- Masking tape
- Ruler
- Scissors
- Graphing calculator

Procedure:

1. Tape the light intensity scale to a wall.
2. Set up the lamp to shine on the scale. (Do not turn on the lamp yet.)
3. Take a piece of foil and cut a five mm diameter hole in the center of it.
4. Cover the face of the lamp by wrapping the aluminum foil around it. (Make sure that the hole is in the center of the face of the lamp and that the aluminum foil does not cover up the vents in the back of the lamp.)
   Safety Tip: Do not leave the lamp on for more than a minute at a time.
5. Darken the room and turn on the lamp apparatus.

6. Hold up a piece of transparency 2 to 3 inches from the wall to cast a shadow near the scale (but not on the scale).
7. Match the intensity of the resulting shadow with a square on the scale. *Tip: It is easier to distinguish the shade of gray in the shadow when one steps back to look at it.*
8. Record the intensity on the table.
9. Repeat steps 5 through 8 until the table is filled.

Thickness (# of sheets)	Light Intensity (% white)
0	100
1	
2	
3	
4	
5	
6	
7	
8	

<u>Data Analysis</u>:

1. Clear all lists from the calculator (STAT → Clearlist → 2^{nd} L_1 → 2^{nd} L_2 → 2^{nd} L_3 → Enter).
2. Enter "Thickness" in L_1.
3. Enter "Light Intensity" in L_2.
4. Calculate the natural log of the light intensity.
    - In the L3 column, arrow up.
    - Enter Ln (L_2).
5. Create a scatterplot using a trendline with the thickness (L_1) and intensity of the attenuator (L_3) data.
6. Turn on the Diagnostics (2^{nd} Catalog → "DiagnosticsOn" → Enter).

7. Conduct a linear regression (STAT → CALC → LinReg → Enter → 2^{nd} L1, → 2^{nd} L3, → VARS→ Function → Y_1).
8. Record your analysis below:

    y = ax + b

    a = __________

    b = __________

    R^2 = __________

    r = __________

9. Write the linear function. y = _________ x + __________
10. Graph your line of best fit.

- Do your data points fall along a relatively straight line? __________
- What does the equation of the best fit line tell you about the relationship between the attenuator thickness and the light intensity of the shadow?

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11. Convert Beer's Law, shown below, to y = mx + b format.

$$\frac{Intensity}{I_0} = e^{-\mu * Thickness}$$

12. Compare the converted formula to the equation on your graph.

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13. What is the attenuation coefficient, μ, of the transparency film? ________

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