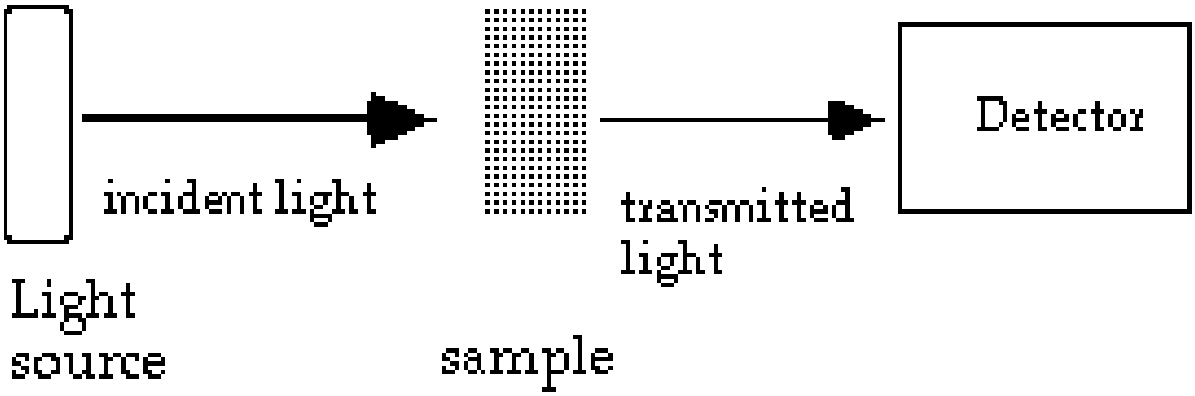
# Exponential Absorption




**(source) http://dwb.unl.edu/calculators/activities/Beers_Law.html**

**Purpose:** To understand that while visible light and radio waves are both types of electromagnetic radiation, their transmission through materials may be different. By collecting data relating the amount of signal transmitted through sequentially thicker sections of plywood, the data will be compared to the theoretical Beer's Law absorption.

**Student Info:**

1) Designed for Physical Science (9/10), Physics (11/12), and Chemistry (10-12)
2) Prior Knowledge: Graphing of Functions, Types of Proportional Relationships
3) Suggested Website:
   **http://dwb.unl.edu/calculators/activities/Beers_Law.html**

**Teacher Info:**

1) Prior Knowledge: VSRT Operation, Analysis.
2) Vocabulary: Inverse, exponential, Beer's Law, absorption, transmission
3) Suggested Websites:
   **http://en.wikipedia.org/wiki/Beer's_law**
   **http://www.chm.davidson.edu/ChemistryApplets/spectrophotometery/BeersLaw.html**

**Time Required:**

1) Setup ≈ 10 min
2) Activity/Lab ≈ 20 min
3) Data Analysis ≈ 30 min
4) Discussion/Wrap-up ≈ 30 min

**Materials Needed:**

1) VSRT System
2) CFL Light Sources
3) Meter stick (100cm) or ruler (30cm)
4) 3/4 inch plywood sheets (4 inches x 3 inches, or large enough to cover both LNBFs), or a five section notebook using the 30-40 pages per section with a divider as the absorbing medium is an alternative to plywood)

**Procedure:** Place the LNBF detectors next to each other (~2.5 inches from center to center) with a bulb (CFL) at a distance of 2 feet from the detectors.

1) Record the power reading without any plywood between the bulb & LNBFs.

2) Place 1 piece of plywood immediately in front of the LNBFs and record power.

3) Repeat step 2) until the signal decreases down to the background of 2-3 K.

**Data Table:**

| ***Pieces of Plywood*** | ***Power (K)*** | ***Actual Transmission (%)*** | ***Theoretical Transmission (%)*** | ***% Difference*** |
|---|---|---|---|---|
| 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |

** Please refer to Basic VSRT Operation instructions for a discussion of Power in (K).

**Graphing:**
Graph % Transmission vs. Thickness or # Sheets using EXCEL, calculator or graph paper.

**Calculations:**
% Transmission = (Power / Maximum Power) x 100, where Maximum Power is the power reading with 0 pieces of plywood in the propagation path.

Theoretical Transmission: use Excel or calculator utilizing the exponential curve fitting function to determine the absorption coefficient for the plywood.

% Difference = | (Measured - Theoretical) / Theoretical | x 100%

**Questions:**

1- What is the meaning of the absorption coefficient?

2- Discuss how well the data fits a Beer's Law curve.

3- Would you expect similar results for similarly sized pieces of Iron? Explain.

4- View the Beer's Law tutorial at http://teaching.shu.ac.uk/hwb/chemistry/tutorials/molspec/beers1.htm. Discuss the relationship of this explanation to your experimental results.

5- How are Newton's Law of Cooling and the mathematical expression for radioactive decay similar to Beer's Law? How are they different?

6- What is the physical similarity between these phenomena that results in a similar mathematical description for question 5?

7- Explain the meaning of the coefficient in the curve fit.

**Conclusions:**
(A thorough analysis of experimental data, including implications)

**Additional Activities:**
Research how Beer's Law is investigated in a Chemistry lab.
Research commercial applications that utilize Beer's Law.

**Example Data: In EXCEL**

**Note: $R^2$ is the correlation coefficient of the data fit**

| Thickness(in) | Power (K) | Transmission (%) |
|---|---|---|
| 0 | 268 | 100 |
| 0.75 | 104.5 | 38.9 |
| 1.5 | 36 | 13.4 |
| 2.25 | 13.5 | 5.0 |
| 3 | 1.25 | 0.5 |