

# Transparent or Opaque



**Purpose:** To understand that while visible light and radio waves are both types of electromagnetic waves, their transmission through materials may be different.

**Student Info:**

- 1) Designed for Physical Science (9/10) and/or Physics (11/12)
- 2) Electromagnetic Spectrum, Wave Speed Equation

**Teacher Info:**

- 1) Prior Knowledge: Basic VSRT Operation

We are all familiar with the concepts of transparent and opaque for materials with regard to visible light. The question we will investigate in this activity is whether these categories also apply to radio waves ( $f \sim 12\text{GHz}$ ), and whether the outcome is the same for a given material in both the radio wave and visible light domains.

Before we use the VSRT interferometer to take measurements, you will record your expectations for light waves and radio waves (microwaves) by categorizing each material as transparent (most or all of the signal gets through), semi-transparent (some signal gets through), or opaque (little or none of the signal gets through).

**Data Table I:**

<i><b>MATERIAL</b></i>	<i><b>VISIBLE LIGHT WAVES</b></i>	<i><b>RADIO WAVES</b></i>
AIR	TRANSPARENT	TRANSPARENT
ALUMINUM FOIL		
CARDBOARD		
CHARCOAL (drawing blow-pipe sticks)		
ESD PLASTIC (anti-static plastic bags that computer chips etc. are packaged in)		
GLASS (clear)		
GLASS (frosted)		
HAND (fingers extended)		
MOTOR OIL (clean, in plastic container)		
MOTOR OIL (dirty, in plastic container)		
OVER-HEAD TRANSPARENCIES (5)		
PLASTIC WATER BOTTLE (empty)		
PLASTIC WATER BOTTLE (full of water)		
PAPER ENVELOPE		
PARAFFIN WAX		
PLYWOOD		
SHEET METAL		

Describe how you made your hypothesis (educated guess) for the radio waves.

We will now use the interferometer to measure the relative transparency at 12 GHz of the previously identified materials. (Hint: having a CFL which has been painted black, or covering the bulb with an opaque cloth may serve to emphasize that the signal of interest is the 12GHz radio wave, NOT the visible light.)

**Time Required:**

- 1) Setup  $\approx$  10 min
- 2) Activity/Lab  $\approx$  40 min
- 3) Data Analysis  $\approx$  20 min
- 4) Discussion/Wrap Up  $\approx$  30 min

**Materials Needed:**

- 1) VSRT System (See Appendix I)
- 2) Materials in data sheet (or substitutes)
- 3) GE, BIA X 27 W compact fluorescent light (CFL). The brand or wattage is not of critical importance.

**Procedure:**

Distance from CFL to LNBF detectors  $\approx$  2 ft .

A variation on the source positioning is to set bulb at a distance that gives a reading of 100K, subsequent readings give percent transmission.

Take a power reading with only air between bulb & LNBF's.

Place material being tested immediately in front of LNBF's, (completely covering the collector surfaces, then take the power reading (n=20 samples works well).

Background (Ave.) \_\_\_\_\_ K

Materials listed are suggestions that were locally available, substitutions are appropriate.

For the COMPARISON column identify the transmission response of the material to the two categories of electromagnetic radiation as either the same or different.

**Data Table II:**

<i>MATERIAL</i>	<i>VISIBLE LIGHT</i>	<i>READING</i>	<i>RADIO WAVES</i>	<i>COMPARISON</i>
AIR				
ALUMINUM FOIL				
CARDBOARD				
CHARCOAL (drawing blow-pipe sticks)				
ESD (anti-static) PLASTIC				
GLASS (clear)				
GLASS (frosted)				
HAND (fingers extended)				
MOTOR OIL (clean, in plastic container)				
MOTOR OIL (dirty, in plastic container)				
OVER-HEAD TRANSPARENCIES (5)				
PLASTIC WATER BOTTLE(empty)				
PLASTIC WATER BOTTLE (full)				
PAPER ENVELOPE				
PARAFFIN WAX				
PLYWOOD				
SHEET METAL				

**Questions:**

- 1) Is the transparency of a material the same for different frequencies of electromagnetic waves?
  
- 2) List possible explanations for the behavior (responses) that you have observed.
  
- 3) List an example where the visible light waves and radio waves transparency (either in alignment with each other, or opposition to each other) are considerations during the design process for a device or application.

**Conclusions:**

Write a summary (conclusion) that addresses your expectations and findings. Include an explanation of your general understanding regarding radio waves and visible light waves.