Detecting Infrared Light With A Homemade Light Sensor

Introduction

Infrared light is a form of electromagnetic radiation having wavelengths between red light and microwaves. Due to its longer wavelength, infrared light behaves somewhat differently than do visible wavelengths. It is invisible to our eyes. Infrared light can't pass through common window glass while white light does. But infrared can pass through black (opaque) plastic – like that found in trashcan liners.

Infrared light is used by astronomers to help see deep inside nebulae – the clouds of gas and dust out of which new stars are continually being formed in our galaxy and beyond. If you can't see it – how do astronomers? The answer is with technology. Sensors are built that are capable of detecting radiation in infrared bands. The Spitzer Space Telescope has two imaging devices aboard – IRAC and MIPS. These "cameras" can detect IR wavelengths between 3.6 and 24 microns.

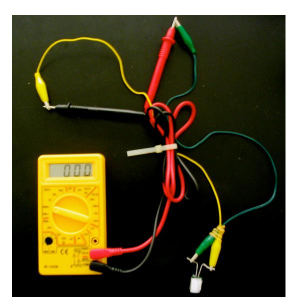
In this activity you will use infrared LEDs, alligator clip wire leads, digital multimeters, and infrared remotes to build a simple circuit that will allow you to detect infrared light from the remote. The key concept behind this detector is simple – if you hook an LED up to a digital multimeter and shine light on the LED electrical current is created as photons flow through the solid-state components of the LED. Of course, if you apply a current to an LED it emits the energy in the form of photons of light. So you are just going to be using it backwards! You will be investigating several things with your sensors: (1) Do different wavelengths (colors) of light produce currents with different voltages? (2) How does the distance from the light source affect the voltage of the current produced by your sensor? And (3) How does infrared light interact with different types of materials?

Materials

Assorted LEDs (Red, Green, infrared)
Digital multimeter
Alligator clip leads (2)
LED lights (Photon, etc)
Infrared remote
Meter stick
Black construction paper strip (2cm x 5 cm)

Procedure

1. Gather all the equipment you will need.
2. Attach alligator clip leads to each of the test leads from the multimeter. Attach the other end of the alligator clip leads to the wire leads of the red LED. Depending on how you hooked it up the multimeter will either read a positive or a negative voltage. THIS IS OK! The magnitude of the voltage is what we are most interested in.
3. Make a light screen using tape and the strip of black construction paper. This is to limit light entering the LED to just the top end of the LED.
4. When you finish your sensor should look like this:



5. Test what happens to the voltage when you bring your sensor closer to a light source. Use Data Table 1 as a guide. Fill in the voltage for each distance listed. Use the white LED light as your light source
6. Also test what happens when you change the color of the LED used in the sensor. See if both colors of LED produce the same voltage. Record your data in Data Table 2.
7. Graph the distance versus voltage for the data from both Table 1 and Table 2.
8. Try the other colors of LED lights as light sources. Investigate how the color of light hitting your sensor affects the voltage. Keep the distance the LED sensor is from the light source 10 cm. Record your data in Data Table 3. Change the LED color used in the sensor and repeat your experiment. Record this data in Data Table 4.

9. Switch to using the infrared LED in your sensor circuit.
10. Shine the TV remote on the infrared LED of your sensor to see if it produces a voltage – thereby showing that your sensor is detecting the invisible IR radiation – it should!
11. Check to see if changing the distance affects the voltage produced by your sensor.
12. Experiment with the glass slide and black plastic to see how it affects the IR beam from the remote.
12. Answer the questions that follow.

Date Table 1

Distance From source (centimeters)	Voltage
2	
4	
8	
16	
LED used in Sensor	

Data Table 2

Distance From source (centimeters)	Voltage
2	
4	
8	
16	
LED used in Sensor	

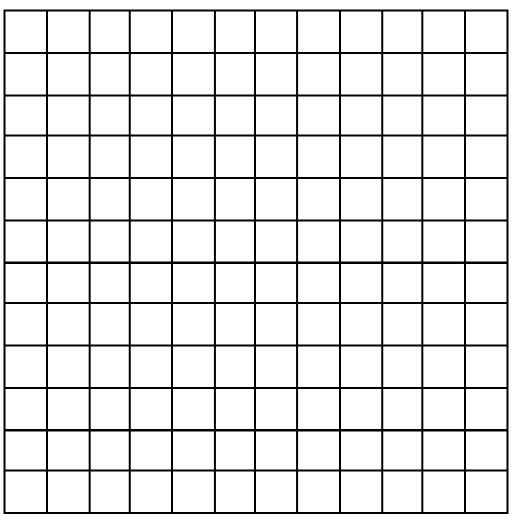
Date Table 3

LED Light Source Color	Voltage @ 10 cm
Red	
Green	
Blue	
LED used in Sensor	

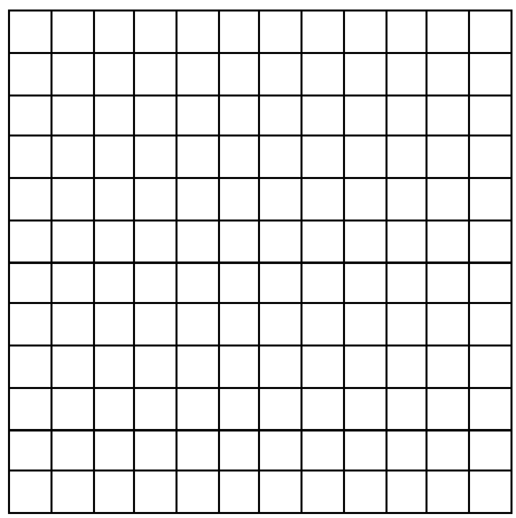
Data Table 4

LED Light Source Color	Voltage @ 10 cm
Red	
Green	
Blue	
LED used in Sensor	

Distance versus Voltage
Green LED



Distance versus Voltage
Red LED



Questions

1. How did increasing the distance from the light source affect the voltage produced by your sensor?

2. The change in voltage with increasing distance should not have been linear. Light intensity decreases as the square of increasing distance. So when the distance is doubled the intensity is 1/4 of what it was. This is called the Inverse Square Law. Why do you think that this did not hold perfectly true for your sensor?

3. What could you have changed in the design of your sensor (if anything) to get “better” data?

4. What color of light source produced the highest voltage when the Red LED was used in the sensor?

5. Did the same color of light produce the same voltage when the green LED was used in the sensor?

6. What are some possible explanations for what you observed when using different colored light sources with your sensors?

7. Does your sensor produce a voltage using the IR LED?

8. How did the black plastic and glass slide affect the amount of voltage produced by your sensor? Did either one affect the transmission of the IR beam? How does this relate to using IR light for astronomy?