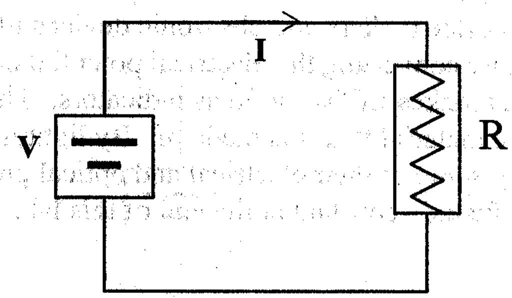
Light Emitting Diodes—Prelab

Consider the following circuit with a battery V = 5V and resistor R = 100 Ω.



g. What is the relationship between electric potential and electric potential energy?

h. How much electric potential energy does each electron lose when passing through the resistor?

Now consider light of frequency (f), wavelength (λ) and velocity (c).

i. What is the relationship between f and λ?

j. What is the relationship between energy E of a photon and frequency f of light?

k. Calculate the energy of a photon of wavelength 500 nm. (1nm = 10^{-9}m)

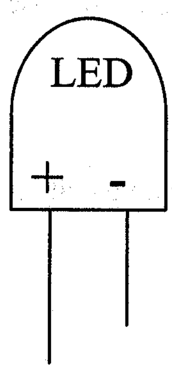
l. If electrons flowing in a circuit were to lose an amount of energy equal to the photon energy of part (b), what would be their change in voltage?

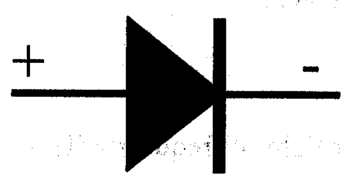
Light Emitting Diodes

Light Emitting Diodes (LEDs) can be found everywhere you look—in digital clocks, appliances like TVs, VCRs, coffee makers and electronic devices like cell phones and computers. LEDs emit light by converting the electrical potential energy into light energy. This property is what makes LEDs useful as indicators. The color of light that an LED emits depends on the material that it is made of. By lighting up LEDs of different color and measuring some of their electrical and optical properties, you will be able to estimate the value of Plank's constant at the end of this lab.

The LED

Familiarize yourself with the LED. Unlike resistors, the LED has a polarity—the longer leg is the positive end and the shorter leg is the negative end. The LED only allows current to flow in one direction, from positive to negative.





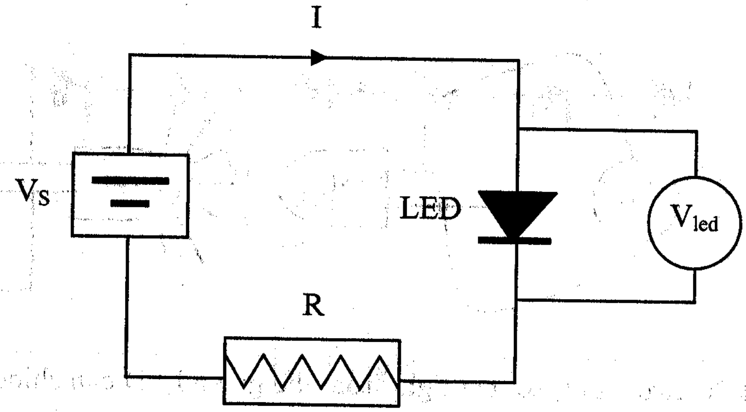
Symbol used to represent LEDs in circuit diagrams

You should have a small ziplock bag with eight different superbright LEDs in it. Each LED has been marked at its base according to the color of light it emits. The following chart explains the color code:

color code (at base of LED)	color of light emitted by LED
brown	infrared
red	red
orange	orange
yellow	yellow
green	green
blue	blue
violet	violet
black	ultraviolet

Making LEDs Light Up

Find the red LED. Construct a circuit with the power supply, a 1000 Ω resistor and the red LED in series. Place the voltmeter across the red LED.



Start with the power supply on the lowest voltage and slowly increase it.

1. At what voltage across the red LED do you first see light?

2. As you continue to increase V_s, does the voltage across the LED change a lot or does it remain close to the value at which you first saw light?

Replace the red LED with the blue LED. Again, start with the power supply on the lowest voltage and slowly increase it.

3. At what voltage across the blue LED do you first see light?

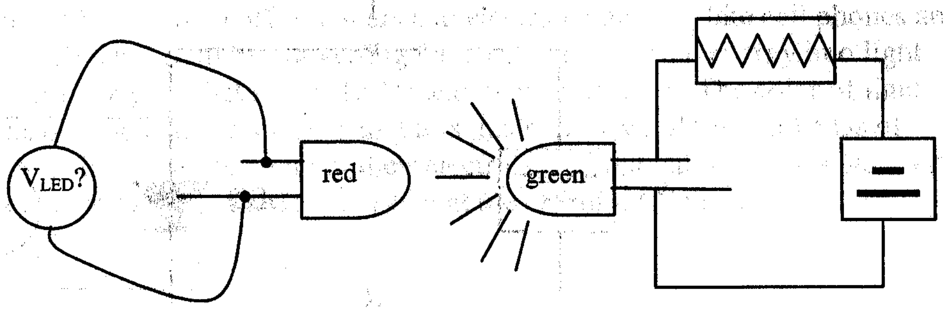
4. Given your voltage measurements on the red LED and the blue LED, in which LED does an electron lose the most energy?

5. Using your knowledge of photons, which color of light (red or blue) contains photons of greater energy?

6. Qualitatively, explain the relationship between voltage drop across an LED and the color of the light it emits.

LEDs in Reverse

Set up the two circuits shown below. Place the multimeter reading the voltage across the red LED. Put the green LED in series with the 1000 Ω resistor and the power supply.



Orient the two LEDs so that light from the green LED can shine into the tip of the red LED as shown. Put the voltage of the power supply on its lowest setting so the green LED is not visibly emitting any light.

1. What is the voltage across the red LED?

Hold the red LED in the same position. Turn up the voltage so that the green LED is shining brightly. Be sure that the light from the green LED is shining into the red LED.

2. What is the voltage across the red LED with green light shining into it?

3. Can you explain your voltage measurements from (1) and (2)?

Now switch the places of the red LED and the green LED.

4. What is the voltage across the green LED with the red light shining into it?

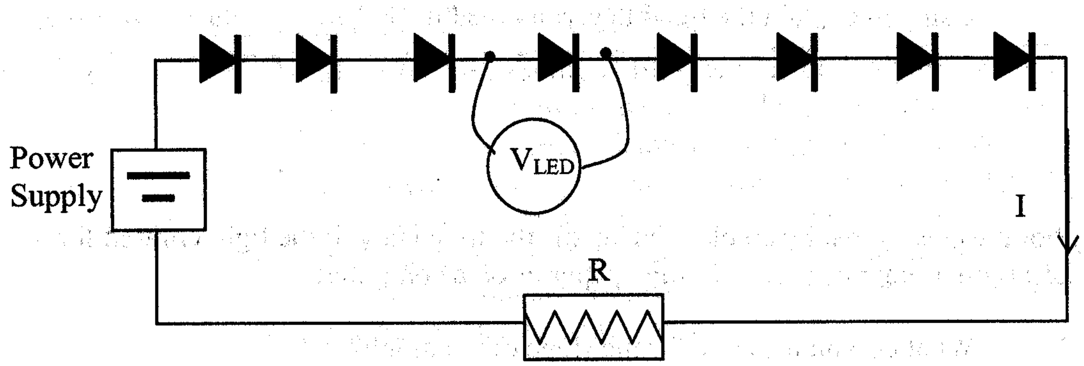
5. Can you explain your observations from (4)?

6. Predict what will happen if you shine ultraviolet light into the green LED.

7. Try the experiment from (6). Were your predictions correct?

Measuring Planck's Constant

Connect the eight LEDs supplied, 1000 Ω resistor and power supply in series. Slowly turn up the voltage output by the power supply until you see most of the LEDs just barely emit visibly emit light.



Measure the voltage across each LED and write it in the table below. In the "Charge" column write the charge of the electron. Then calculate the energy each electron loses when it passes through the LED in the "Energy lost" column.

LED	LED voltage (V)	Charge (C)	Energy lost (J)
infrared			
red			
orange			
yellow			
green			
blue			
violet			
ultraviolet			

Now take all of the LEDs out of the circuit except one. Shine the light from the LED on a surface and look at the spot of light through a spectrometer. In the column marked "λ," write the central wavelength of the LED. Be sure to read the spectrometer to the nearest tenth. The spectrometer scale reads in hundreds of nanometers. Convert the wavelength to meters and calculate the corresponding frequency *f*. Repeat for all LEDs.

LED	λ (nm)	λ (m)	f (Hz)
infrared	875		
red			
orange			
yellow			
green			
blue			
violet			
ultraviolet			

1. Compare the voltages of the different LEDs with the frequency of the light emitted by the LED. What trend to do observe?

2. Can you explain the trend that you noted in (1)?

Plot the energy lost by an electron versus the frequency of the light emitted for all the LEDs on a separate piece of graph paper or on a computer.

3. What do you measure for the slope of the graph?

4. What is the meaning of the slope?