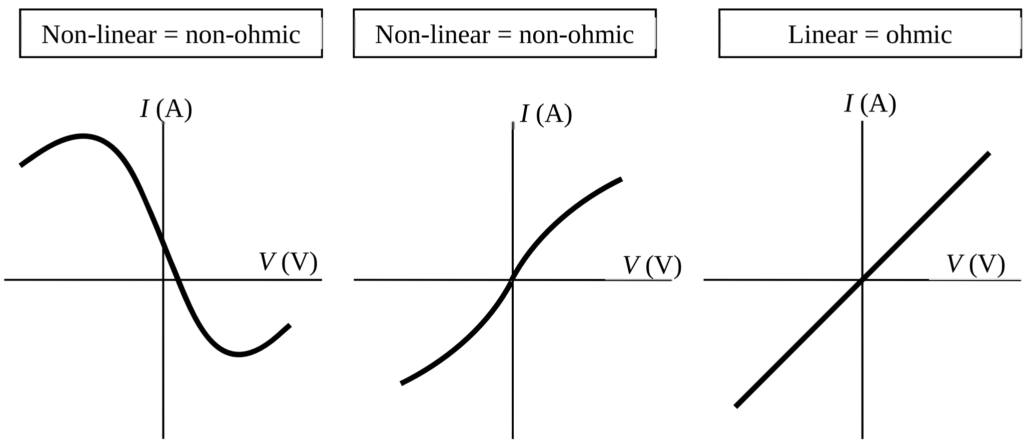
Characteristic of a Diode

Apparatus: Diodes (not LEDs), resistors, ceramic capacitors, PASCO Science Workshop 750 Interface & Power Supplies, 2 digital multimeters per group (handheld & bench top if necessary), DMM red leads, DMM black leads, breadboards, jumper wires, oscilloscopes, oscilloscope probes, very small flathead screwdriver.

Purpose: To explore the *IV*-plot of a diode and determine if the diode is an ohmic device.

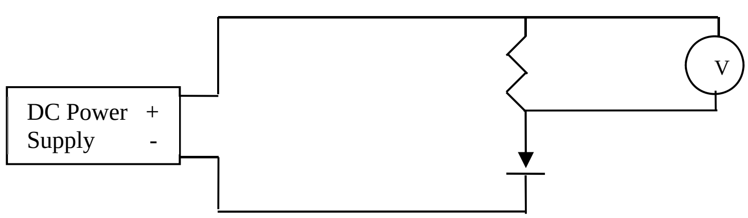
Theory: An ohmic device is a device which obeys Ohm's Law ($V_{across\ the\ device} = I_{through\ the\ device}R$). This must be true for all *I* and *V* the device experiences. It is easiest to verify if a device is ohmic by looking at its *IV* plot. Only devices with linear *IV* plots are ohmic (see figure below). Notice an annoying feature of *IV* plots: voltage (the independent variable) is on the *x*-axis while the current (the dependent variable) is on the *y*-axis. This is standard practice. Unfortunately, this means that the resistance of a device at any voltage is not given by the slope of the *IV* plot but rather the inverse of the slope of the *IV* plot.



Procedure:

1) Measure the resistance *R* of a resistor (about 1 kΩ) and record the result. Use a breadboard to put the resistor in series with the diode. Be sure that the resistor connects to the **unbanded** end of the diode. For kicks try measuring the resistance of a diode with the DMM. Then switch the leads and try it again!

2) Connect the free end of the resistor to the positive terminal of the power amplifier and the negative and the ground to the banded end of the diode. See figure.



3) Set the power amplifier to DC and the voltage setting to 0.0 volts. Record both the voltage across the resistor V_R and the voltage of the power supply V_{pwr}. From these you should be able to determine the voltage across the diode V_d. From Ohm's Law the current in the circuit can be calculated from $I = V_R/R$. This one should be easy.

4) Now increase the voltage by 0.1 volt increments from 0 to 2 volts, and record V_R and V_{pwr}. Use this information to generate the table of values for V_d and I_d.

5) Now return to 0.0 volts. Reverse the polarity of the circuit by switching the cables in the DC power supply. This time going by 0.5 volt increments, repeat the previous step. Keep in mind that when you tabulate these values in your *IV* plot the values will correspond to negative voltages.

6) Plot I_d versus V_d (remember which variable goes on which axis for an *IV* plot). Is the diode an ohmic device? There should be a voltage where the slope suddenly changes. This is called the knee. Locate the knee on your graph and label it.

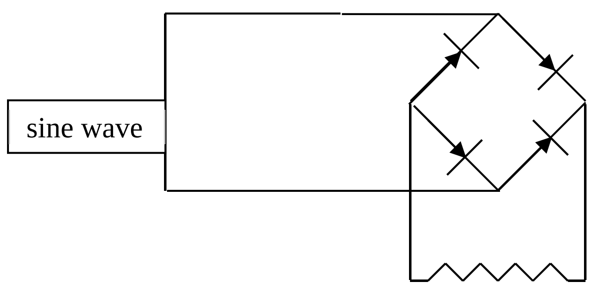
7) Plot *I* vs V_{pwr} and locate the knee on the graph. From Ohm's law for both diode & resistor, $I = V_{pwr} / R_T$, where R_T is the equivalent resistance of the circuit. From your graph calculate the R_T before and after the "knee" and compare it to R_T that you measured in Part 1. Compare it to *R*, the resistance of the resistor. Note: I believe the power supply has an internal resistance of about 50 Ω.

8) Now use the triangle wave on the power supply. Set the frequency to 1 kHz and the amplitude to 2.0 V. Ask your instructor to show you how to set-up an oscilloscope. Notice this set-up makes the same graph you did in 1 millisecond (if the frequency of your function generator is 1 kHz)! Very powerful…Make a sketch of the graph on the oscilloscope. The sketch should be ½ page in size with correctly labeled the axes with units. Indicate a scale on each axis for credit. Also include a title above the sketch.

9) Make a "half-wave" rectifier by switching the power supply to AC sine wave generator. You should see a sine wave with half it curves flattened out. This is a method of partially converting an AC current to DC current. Make a sketch of the graph on the oscilloscope. Think: ½ page, labels, units, scale, & title.

10) Try connecting a capacitor across the resistor in parallel. What happens? Try varying the frequency. The capacitor is more effective at smoothing out the curve at higher frequencies. Why? What is the relationship between τ (RC) and the generator frequency for effective smoothing? Make a sketch of the graph on the oscilloscope at 1 kHz. Think: ½ page, labels, units, scale, & title.

11) A more effective method of converting AC to DC is to construct a full wave rectifier.



The above circuit shows a possible arrangement for a full wave rectifier. The rectified output voltage appears across the resistor. Try to understand this circuit by tracing the path of the current for each half of the generator cycle. Make a sketch of the graph on the oscilloscope at 1 kHz. Think: ½ page, labels, units, scale, & title. Specifically state whether or not you are still using the capacitor in parallel with the resistor.

For each numbered step above be sure to answer any questions asked. In your notes clearly organize and label which graphs and tables go with which number step. It may help to print them all out then cut them up with scissors and label them by number (and include good titles). Don't forget to do quality sketches on parts 8 through 11. By quality I mean they should look just like a graph: ½ page in size with axis labels (with units and scale) and titles.