Allow 40 minutes for this midterm.

An Asymmetric Circuit – Midterm Exam

The circuit in this lab is *asymmetric* because when current flows through it one way it acts like a resistor, but when current flows through it the other way it does not.

February 2017

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Instructions

You may bring with you to the lab one 3"×5" note card containing notes. You may write on both sides of the card.

During the test, you may ask for assistance, but you may not receive full credit for an activity for which you received assistance.

Do not bring this handout to the test. A new copy will be provided.

Equipment: Computer with MS Excel
Variable DC Power supply: 0 to at least 10 VDC with at least 300 mA
Voltmeter (3 or more digits)
Ammeter (3 or more digits)
Diode with at least 0.5 A forward current and 15 V reverse voltage (e.g., 1N4003)
This is an ordinary diode, not an LED (**L**ight **E**mitting **D**iode), so it does not emit light.
Light bulb: 14 V, 200 mA (e.g., Radio Shack #1815, part number 272-1118)
100 Ω, 2 Watt Resistor
Banana plug circuit board with diode, resistor, and light bulb pre-installed
Banana plug wire connectors (8 short; 5 red and 3 black is a nice combination)

Figure 1 The banana plug circuit board holding the resistor, the light bulb, and the diode. The resistor and diode can be seen on the top of the box, while the light bulb is mounted inside. The orientation of the diode is not known in advance but must be determined from the data.

0. Introduction

0.1 In preparation for the lab practical midterm exam ...

- Be able to wire circuits from wiring diagrams
- Be able to correctly connect voltmeters and ammeters
- Be able to use MS Excel to record data, do calculations, and plot graphs
- Understand the difference between ohmic and non-ohmic

0.2 *Overview of the midterm exam*

The circuit for this lab behaves like a resistor when connected to the power supply one way, but it does not behave like a resistor when connected in the opposite way. Your task is to construct the circuit and then determine how it behaves when connected to the power supply.

- Construct the circuit in Figure 2
- Connect the circuit to the power supply and collect *Voltage* and *Current* data
- Reverse the connection to the power supply and again collect *Voltage* and *Current* data
- Plot two graphs of *Voltage* versus *Current*
- Make two tables of *Resistance* versus *Current*
- Save your spreadsheet
- Answer questions based on your V versus I graphs and your tables of R

0.3 *Ohm's Law*

0.3.1 $V = IR$ is the statement of Ohm's Law. V is the voltage difference between two points, I is the current flowing between the two points, and R is the resistance between the two points.

0.3.2 One can always calculate resistance using $R = V/I$, but for some objects one gets different resistances for different values of I.

0.3.3 A device or circuit is said to obey Ohm's Law if the relation $V = IR$ holds true always using the same value of R, no matter what current flows. In other words, the ratio $R = V/I$ always stays the same even though the voltage and current change. Things that obey Ohm's Law are called *ohmic*; things which do not are called *non-ohmic*.

0.4 *Units conversions*

0.4.1 Your ammeter will be set to read in mA (milliamperes), and you will need to convert all current readings to amperes.

0.4.2 You voltmeter will be set to read in volts, so no voltage conversions will be necessary.

0.5 *The diode orientation will be unknown ...*

As you know, diodes are electrical one-way-streets, allowing current to flow in one direction but not the other. The diodes in this lab have their orientation marks covered, so you will be unable to tell which direction through the diode is forward bias and which is reverse bias.

Therefore, you may as well connect the diode any way you like. The data you collect during the lab will enable you to determine which direction through the diode is forward (current can flow) and which is backward (current cannot flow).

0.6 *How the circuit for this lab works*

Refer to the circuit in Figure 2. If the diode is forward biased, current will flow through the diode and also through the light bulb, so the circuit will ***not*** behave like a simple resistor. If the current flows the opposite direction, the diode will not allow current to flow though the light bulb. In that case, current will flow only through the resistor, and the circuit will behave like a resistor. In the first case, the circuit does not obey Ohm's Law; in the second case, it does.

0.7 Here is a good way to set up your spreadsheet. The data in this example are fictitious.

1st data set				2nd data set		
I	V	R		I	V	R
(amperes)	(volts)	(ohms)		(amperes)	(volts)	(ohms)
0.0412	2.05			0.0131	1.82	
0.0757	4.21			0.0192	3.98	
0.102	5.92			0.0244	6.15	
0.139	8.01			0.0351	7.90	
0.147	10.07			0.0466	9.86	

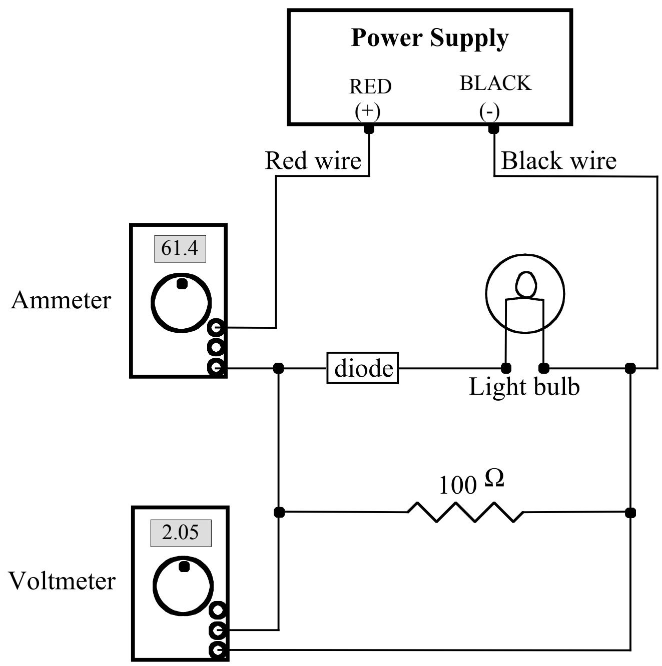

Figure 2: Circuit diagram. First wire the ammeter-diode-bulb loop. Then add the resistor. Finally, add the voltmeter. You will not be able to see the light bulb because it is inside the closed box on which the diode and resistor are mounted.

1. Activity #1: Construct the circuit

1.1 Make sure that the power supply is switched off and the voltage control knob on the power supply is set at its minimum position by turning it counterclockwise all the way.

1.2 Setting aside the question of which direction for the diode is forward bias, construct the circuit in Figure 2. Suggested procedure:

> 1.2.1 Ignoring the voltmeter and the 100 Ω resistor, wire the loop that contains the power supply, the ammeter, the diode, and the light bulb.
>
> 1.2.2 Add the 100 Ω resistor.

1.2.3 Add the voltmeter.

1.3 Be sure the red wire plugs into the red socket of the power supply, and the black wire plugs into the black socket of the power supply.

1.4 **Have <u>your lab instructor check your circuit before proceeding any further</u>.**

2. Activity #2: Collect data

2.1 Turn on the computer, run MS Excel, and enter your name in the spreadsheet.

2.2 Set up the MS Excel column headings (see the sample data, in section 0.7).

2.3 Set the voltmeter to the 20 or 30 VDC scale. Look for this symbol on the meter: $\overline{\mathbf{V}}$ or **V⎓** .

2.4 Set the ammeter to the 200 or 300 mA DC scale. Look for this symbol on the meter: $\overline{\mathbf{A}}$ or **A⎓** .

2.5 Turn on the power supply.

2.6 Collect the first data set and enter it into MS Excel. Voltages should be set for ***approximately*** 2 V, 4 V, 6 V, 8 V, and 10 V (do not waste time making the voltages exactly even integers). Record actual voltages and corresponding currents in your MS Excel spreadsheet. If your wired the meters correctly, all voltages and currents will be positive.

2.7 Reverse the power supply connections. You now want the red wire to go to the black plug and the black wire to go to the red plug. This makes current flow through the circuit in the opposite direction.

2.8 Collect the second data set and enter it into MS Excel. Voltages should be set for ***approximately*** 2 V, 4 V, 6 V, 8 V, and 10 V (do not waste time making the voltages exactly even integers). Record actual voltages and corresponding currents in your MS Excel spreadsheet. ***All the voltages and current will be negative, but discard the minus signs when you enter your data.***

3. Activity #3: Graph Voltage versus Current

Create a scatter plot of the current ***in amperes*** on the horizontal axis and the voltage in volts on the vertical axis. **Do this for both sets of data.** Putting the plot on the spreadsheet page instead of on a separate page is preferred, but either way is fine.

4. Activity #4: Calculate Resistance versus Current

Use spreadsheet formulae to fill in the resistance columns for both data sets. **Do not make a graph of resistance.**

5. Activity #5: Save/Print your spreadsheet

5.1 *If your instructor tells you so*, save your MS Excel spreadsheet to your appropriate folder on the www drive. Use your name in the file name. *Example* Kim Kimball.xls. **Print your spreadsheet**.

5.2 Leave MS Excel open, and proceed to Activity #6. You may want to refer to the graphs or the tables of resistances while you answer the questions in Activity #6.

