HANDS-ON LAB INSTRUCTION SHEETS – MODULE 1

MEASURING RESISTANCE AND VOLTAGE

NOTES:

1) *Each student will be assigned to a unique Lab Equipment number **MS01-MS30** which will match to a Tool Kit and a Radio Shack Electronic Learning Lab Console.*
2) *All work is to be done individually,*

There are no "lab reports" in this course. You must turn in the Results Sheets at the end of the period, finished or not. Keep Instruction Sheet(s) for use when studying for exams.

3) *Enter all your lab results on both the Instruction Sheet(s), and the Results Sheet(s).*
4) *All measurements should be made with the Digital Multimeter in your Pratt Kit.*

To conserve your multimeter's 9V battery, be sure to turn the meter off if not in use for over 5 minutes. *Check that your meter is turned off and in your Tool Kit when leaving class.*

This first module is designed such that you become familiar with the Radio Shack Electronic Learning Lab Console and breadboard, measuring resistance and voltage with the Multimeter, using the wire stripper and reading basic schematic diagrams.

BILL OF MATERIALS

Radio Shack Electronic Learning Lab Console
AC Adapter (*9 volts at 150 mA*)
Digital Multimeter
Wire Stripper
Four (4) 1000 Ohm, ½ Watt Resistors *with color code:* ***brown black red gold*** (*1KΩ at 5%*)
Miscellaneous Connecting leads and wires

SECTION A. USING THE MULTIMETER

In the tool kit you will find a Digital Multimeter which should look similar to the one shown in Figure 1.1. The Multimeter will be used in this course for routine measurements of resistance (**Ohmmeter**) and direct current (**DC**) voltages (**Voltmeter**). Your Multimeter is a very powerful tool as it can also measure current, transistor current gain ($\mathbf{h_{FE}}$), and alternating current (**AC**) voltages.

There are two special leads with a plug for the Multimeter on one end and a 'push-in' hook on the other.

The **RED** lead plugs into the **VΩmA** socket and the **BLACK** lead plugs into the **COM** socket on the meter. COM is another way of saying common connection, in most cases this is the electrical ground or **GROUND** for your circuit which is connected to the negative power of your power supply.

Figure 1.1 Digital Multimeter

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MEASURING THE RESISTANCE OF RESISTORS

CAUTION: *Whenever measuring resistors please be sure that the power to a circuit is **OFF** to avoid damaging your meter.*

To use your Multimeter to measure the resistance (ohms) it must be set on one of the **Ohmmeter** function modes in the lower left meter ranges of **200**, **2000**, **20K**, **200K** and **2000K** ohms. We will measure the resistance of a resistor with the markings: ***brown black red gold*** (*1KΩ = 1000 ohms at 5%*). We typically select the range which is just greater than our anticipated value, so in this case use the meter's **2000** range. Use the hook ends of the meter leads to grab the two leads of the resistor.
Resistors that we use in this class have NO polarity, so it does not matter which of their two leads is connected to the meter's **RED** and **BLACK** hooks.

1a.) What value of resistance do you measure? _____ Ohms

If your result is more than 10% off (i.e. less than 900Ω or greater than 1100Ω);
***Consult your instructor**.*

THE RADIO SHACK ELECTRONIC LEARNING LAB CONSOLE

Each student will be assigned to a unique Radio Shack Electronic Learning Lab on which to perform the hands-on labs during the semester without needing to re-wire your circuits.

The Lab Consoles are stored in the large white cabinet in the rear of ARC E-08 and can be accessed by request of Ms. Margaret Dy-So (**mdyso@pratt.edu**), Assistant to the Chairperson of the Department of Mathematics and Science whose office is ARC Room E-37. (*You should email Ms. Dy-So in advance of your desire to come in, just in case another class is using the lab at the time you would like to work there*.)

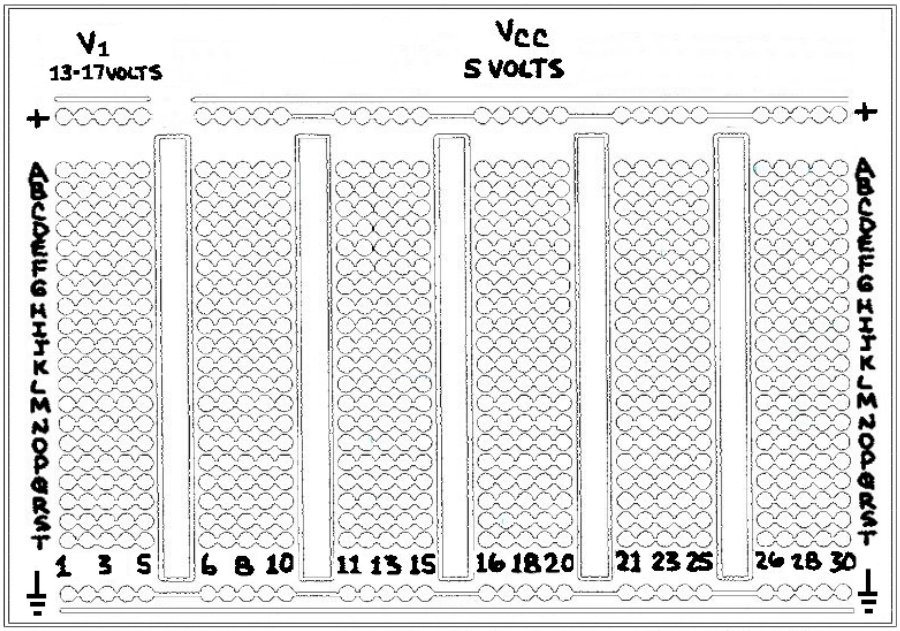

Figure 1.2 Radio Shack Learning Lab Console Solderless Breadboard

We will now see how simple it is to insert resistors into the breadboard to interconnect them and make it easier to create temporary circuits without soldering.

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INSERTING RESISTORS ONTO THE BREADBOARD

Gently bend the leads of the **1KΩ** resistor you just measured the resistance of close to the device's body to form a "**U**" and insert the resistor (**R_1**) into the breadboard's connection points **A25** and **F25** with four (4) empty points between the two leads (see Figures 1.2 and 1.3). This will result in the schematic (and pin locations) of figure 1.2. *Recall that there is NO polarity for our resistors although having the **gold** band at the lower end looks nice.*

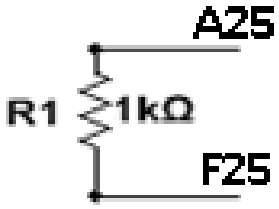

Figure 1.3 One Resistor Circuit Schematic with Console Breadboard Connection Points Indicated

*NOTE: These connection points are in the fifth column of breadboard in the last column, the fifth connection at the top (**A25**) and sixth row from the top (**F25**) connection points.* Note, too, that the four connection points to the left of both **A25** (that is **A21-A24**) and **F25** (that is **F21-F24**) allow up to four more connections to each of those leads.

1b.) Repeat your resistance measurement (A25 to F25) _____ Ohms

Did you read the same value as in 1a? YES ____ or NO ____ ?

NOTE: Occasionally we may find slight differences in measurements made directly, and in circuit, but in this case the readings should be the same as nothing else is connected to the resistor at this time.

MEASURING THE RESISTANCE OF TWO RESISTORS IN SERIES

Now BEND AND insert a second ***brown black red gold*** (*1KΩ = 1000 ohms at 5%*) resistor **R_2** into the breadboard at **F23** and **K23** to create the two resistor series circuit shown in Figure 1.4.

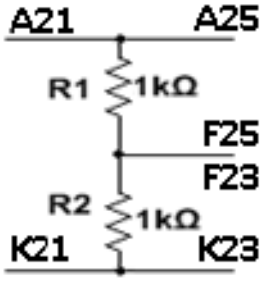

Figure 1.4 Two Resistor Schematic with Console Breadboard Connection Points Indicated

Note that the pins numbers at the **right** are where the component leads are inserted and the pin numbers at the **left** are used for measuring the resistance in this circuit. Using the Multimeter on either the ***20K*** *or* ***2000*** scale at the lower left, measure the resistance of two **1KΩ** resistors in series by measuring between **A21** and **K21**.

1c.) Resistance of two 1KΩ resistors in series _____ ohms

*If the resistance is not nearly 2000 ohms; **Consult your instructor**.*

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MEASURING THE RESISTANCE OF TWO RESISTORS IN PARALLEL

NOTE: DO NOT REMOVE THE RESISTOR BETWEEN F23 AND K23.

Now bend and insert a third ***brown black red gold*** (*1KΩ = 1000 ohms at 5%*) resistor **R_3** into the breadboard at **A21** and **F21** to create a two resistor parallel circuit with the resistor in **A25 - F25** as indicated in Figure 1.5.

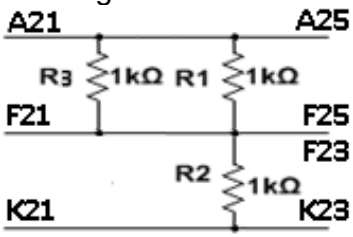

Figure 1.5 Resistor Schematic with Console Breadboard Connection Points Indicated

Use the Multimeter on the **2000** scale at the lower left to measure the resistance of the two **1KΩ** resistors **R_1** and **R_3** in parallel between **A21** and **F21** ***(NOT K21)***.
*NOTE: **A21** through **A25** are connected together internally as are **F21** through **F25**.*

1d.) Resistance of two 1KΩ resistors in parallel _____ ohms
If the resistance is not nearly 500 ohms; consult your instructor.

FOUR RESISTOR SERIES CIRCUIT

Carefully remove resistor **R_3** from the breadboard at **A21** and **F21** and insert it instead between points **K25** and **P25** creating a three-resistor series circuit. Finally, bend and insert a fourth ***brown black red gold*** (*1KΩ = 1000 ohms at 5%*) resistor **R_4** to create a four-resistor series circuit with the resistor in **P23 - T23** as indicated in Figure 1.6.

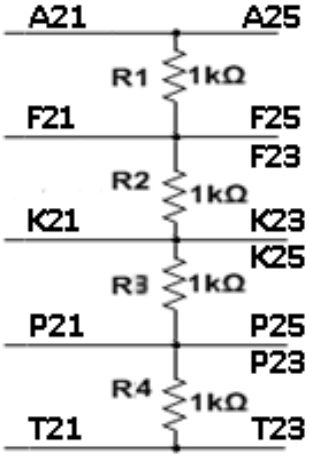

Figure 1.6 Four Resistor Series Circuit with Console Breadboard Connection Points Indicated

Use the Multimeter on the **20K** scale at the lower left to measure the resistance of the four **1KΩ** resistors **R_1** through **R_4** in series between **A21** and **T21**.
*NOTE: **A21** through **A25** are connected together internally as are **T21** through **T25**.*

1e.) Resistance of four 1KΩ resistors in series _____ ohms
If the resistance is not nearly 4000 ohms; consult your instructor.

DO NOT REMOVE THE RESISTORS! – Instructor Check Point 1A

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SECTION B. LEADS, WIRES AND MEASURING VOLTAGES
USING INSULATED WIRE TO CONNECT DEVICES

To interconnect components on the Console we use ***#22 gage insulated wire*** in one of three colors, **RED** for direct connections to positive power voltage, **BLACK** for direct connections to electrical ground, and **YELLOW** for all other interconnections.

Cut a three (3) inch length from the **RED** wire spool with the cutting portion of the wire stripper. Now carefully close your wire stripper around the wire insulation about **0.25"** from one end while at the same time pulling the remaining length of wire. *The hope is that you will remove the insulation without nicking or cutting the wire itself.* Do this on both sides, and as needed, with several other lengths of wire until you get the feel for removing just the insulation without damaging the wire. Although a quarter inch is enough bare wire for inserting into the connection points on the breadboard, you will probably need more like a half inch of bare wire for effective connections to the various **springs** used to connect to the Console's many internal components.

BARE WIRE FOR EASY POWER CONNECTIONS

Carefully remove ALL the insulation from the three inch piece of wire. Then cut this piece of now bare wire into one inch lengths and bend each into a "**U**" loop. Connect one loop to a pair of connection points between the leftmost **+** sign and the "**1**" power label (e.g., pins 2 and 4, see Figure 1.2) to permit easy access to the AC Adapter power with the **RED** alligator clip. Insert a second loop of wire into any pair of the GROUND connections at the bottom of the breadboard for connecting to the **BLACK** alligator clip. You now have an easy way to connect your resistors to positive or plus voltage and ground with these two alligator clips. A third wire loop can be placed into any pair of the 25 connections between "**1**" and the rightmost **+** sign for use in checking that voltage (*currently zero, this will become the connections our 5 volt regulated voltage source*).

USING YOUR AC ADAPTER AS A POWER SOURCE

The Console has been modified to accept a **9 volt, 150 milliampere AC Adapter** for use in powering your circuits. Modifications have also been made to allow the **ON-OFF Switch** at the top left to control power from the adapter connecting to the centrally mounted solderless breadboard.

MEASURING VOLTAGES

To use your Digital Multimeter to measure the voltage (in volts) available on the console breadboard it must be set up in the Voltmeter function mode with the rotary switch set on one of the upper left-hand **DC Voltage** ranges: **200m**, **2000m** (2 volts), **20**, **200**, and **1000**. As we expect the AC Adapter output voltage to be 13-17 volts, use the "**20**" range with the **RED** lead from the meter connected directly (or via a **RED** alligator clip lead) to the loop inserted into a pair of the five connection points at the top left of the breadboard, and the **BLACK** lead from the meter connected directly (or via a **BLACK** alligator clip lead) to a loop inserted into an pair of the thirty (30) connection points at the bottom of the breadboard (electrical **GROUND**).

All voltage measurements should be positive. *The voltmeter will show a* ***negative voltage*** *if your polarity is reversed, if that happens, please reverse the lead connection.*

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MEASURING UNLOADED AC ADAPTER POWER SUPPLY VOLTAGE

Find the Console's rear-mounted socket connector and plug your 9V cube adapter into it and then into the AC power strip on your desk.

When the Power Strip and Console switches are both in the **ON** position the output of the AC Adapter is connected directly to the leftmost top five connecting points (labeled **V_1 13-17 volts** on the figure, but **NOT** on the actual breadboard, where they are between the **+** sign and number **1**, see Figure 1.2 on page 2. The AC Adapter was designed to deliver 9 volts at 150 milliamperes (0.150 Amperes). The adapter voltage is variable, that is, it will be *greater* than 9 volts when *less current* is drawn from it.

Without ANY load, *that is **open circuited** or **UNLOADED***, the adapter voltage should be between 13 and 17 volts. We will be calling **V_1** the AC Adapter's unregulated voltage.

Make your measurement of the AC Adapter's unloaded, unregulated, voltage **V_1** using the **20** volt range (*upper left BLUE scales*) on the Multimeter.

1f.) 9V cube adapter unloaded voltage (*13-17V expected without a load*) _____ **volts**

MEASURING THE VOLTAGES ACROSS RESISTORS

You have already created a four resistor series circuit on your Console Breadboard using four each 1000 ohm resistors per Figure 1.6 on Page 4.

Use the **RED** alligator clip connected to the positive **V_1** voltage (or cut and strip a piece of **RED** wire to connect one of the five **V_1** connection points between the rightmost + and "**1**") and connect it to any open connection in the row **A21**. Use **RED** wires or leads for **+** voltages. Use a **BLACK** alligator clip connected to the ground points at the bottom of the Console Breadboard. Any wires or leads connecting **–** voltage should be **BLACK**.

Referring to Figure 1.6 on page 4, measure the adapter output voltage with the **RED** lead at **A21** for the circuit indicated connecting **BLACK** or **GROUND** as noted:
1g.) A **"four series 1KΩ resistor - 4000Ω load", BLACK** at **T21:** _____ **volts**

1h.) A **"three series 1KΩ resistor - 3000Ω load", BLACK** at **P21:** _____ **volts**

1i.) A **"two series 1KΩ resistor - 2000Ω load", BLACK** at **K21:** _____ **volts**

1j.) A **"1KΩ resistor - 1000Ω load", BLACK** at **F21:** _____ **volts**

VOLTAGE DIVIDER PROOF

Measure the voltage drop across each of the 1KΩ resistors in Figure 1.6**:**
1k1.) R_1: A21 to **F21:** _____ **volts** **1k2.) R_2: F21** to **K21:** _____ **volts**
1k3.) R_3: K21 to **P21:** _____ **volts** **1k4.) R_4: P21** to **T21:** _____ **volts**
1k5.) Does adding the (four) individual voltage drops **1k1** though **1k4** equal the same voltage you found in the four-resistor load circuit of **1g**.? **(Yes** _____ **or No** _____ **?)**

DO NOT REMOVE THE RESISTORS - YOU NEED THEM NEXT WEEK
This is Instructor Check Point 1B

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