



## American International University- Bangladesh

### Faculty of Engineering (EEE)

#### EEE 2109: Introduction to Electrical Circuits Lab

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**Title of the Experiment: Familiarizing with the basic DC circuit terms & concepts: Introduction to laboratory equipment.**

**Abstract:** To gain experience in building DC circuits and making measurements of current and voltage. Also, strengthen the ability to reason about how adding or removing resistors will affect the current & potential at different locations in a DC circuit.

**Introduction:** This lab is designed to review, solidify & improve your understanding of DC circuits & ohms law. Research has shown that even after students have completed their study of DC circuits, they often have difficulty with some specific concepts and ideas. The exercises here are designed to address these difficulties in a step by step fashion and help you learn to reason more easily & correctly about circuits.

In each part of the lab, you will be given a circuit diagram, involving a power supply. You will be asked to make some predictions about the behavior of the circuit before you actually construct the circuit and make any necessary measurements. Hopefully, some of the circuits will surprise you with behavior.

#### **Theory and Methodology:**

**Ohm's Law:** Ohm's Law deals with the relationship between voltage and current in an ideal conductor. This relationship states that:

At fixed temperature in an electrical circuit, the current passing through a conductor between two points is proportional to the potential difference (i.e. voltage drop or voltage) across the two points, and inversely proportional to the resistance between them. In mathematical terms, this is written as:

$$V = IR$$

Where I is the current in amperes (A), V is the potential difference in volts (V), and R is the resistance measured in ohms ( $\Omega$ ) which is constant here. The potential difference is also known as the voltage drop and sometimes denoted by E or U instead of V.

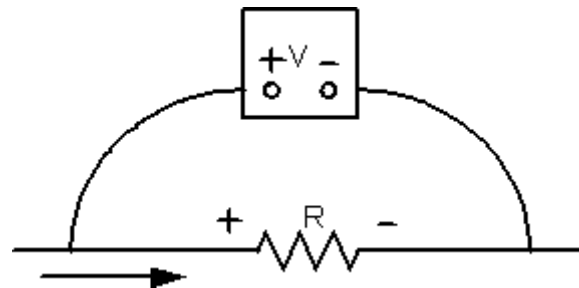
**Current:** The amount of electric current (measured in amperes) passes through a surface, e.g., a section through a copper conductor, is defined as the amount of electric charge (measured in coulombs) flowing through that surface over time. If Q is the amount of charge that passed through the surface in the time T, then the average current I is:

$$I = Q/T$$

**Voltage:** Voltage (sometimes also called electric or electrical tension) is the electrical potential difference between two points of an electrical conductor, expressed in volts. It measures the potential energy of an electric field that causes the flow of electric current through a conductor. Depending on the difference of electrical potential it is called extra-low voltage, low voltage, high voltage or extra-high voltage.

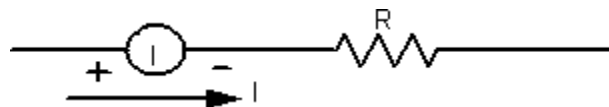
Between two points in an electric field, such as exists in an electrical circuit, the difference in their electrical potentials is known as the electrical potential difference. This difference is proportional to the electrostatic force that tends to push electrons or other charge-carriers from one point to the other. Electrical potential difference can be thought of as the ability to move electrical charge through a resistance. At a time in physics when the word *force* was used loosely, the potential difference was named the electromotive force or **EMF**—a term which is still used in certain contexts.

**Voltmeter:** Voltmeter is a device that is used to measure the voltage difference between two points of an electronic component. The potential difference can be measured by simply connecting the leads across the two points of a load.



**Figure 1:** Voltage measurement across the two points/ends of a resistor

**Ammeter:** Ammeter is a device that is used to measure the current level of the circuit. Since ammeters measure the flow of charge, the meter must be placed in the network such that the charge will flow through the meter. Mistakenly placing the ammeter in parallel with a circuit will blow the fuse, possibly damaging the meter and causing injury.



**Figure 2:** Demonstration of measuring current using an Ammeter

**Wattmeter:** The wattmeter measures the power delivered by a source and to a dissipative element.

**Circuit Breaker and Fuses:** The incoming power to any installation or house or machinery must be limited to ensure the current through the line is not above the rated value. Otherwise, the instrument may be damaged or serious hazards like fire or smoke may result in. To limit the current level circuit breakers and fuses are used. Fuses have an internal metallic conductor through which the current will pass; a fuse will melt if the current through the system exceeds the rated value printed on the casing. Of course, if the fuse melts through, the current path is broken and the load in its path is broken and the load in its path is protected.

Fuses have now been replaced by circuit breakers. In a circuit breaker, when the current exceeds rated value an electromagnet in the device will have sufficient strength to draw the connecting metallic link in the

breaker out of the circuit and open the current path. When the conditions have been corrected the breaker can reset and used again.

### Resistance color coding:

You will need to select the resistors from the component drawers with the values as close as you can get to your selected theoretical values. You may decide to set them down on the table and lose track of which resistor is which. You can determine the value either measuring it with a meter or looking at the color-coded stripes on the package. The following table shows how to read this color code.



Color	1 <sup>st</sup> dig(X)	2 <sup>nd</sup> dig(Y)	Mult	Tolerance
Black	0	0	XY.0 ohm	
Brown	1	1	XY0 ohm	
Red	2	2	X.Y K ohm	
Orange	3	3	XY K ohm	
Yellow	4	4	XY0 Kohm	
Green	5	5	X.Y M ohm	
Blue	6	6	XY M ohm	
Violet	7	7	XY0 M ohm	
Gray	8	8	X.Y G ohm	
White	9	9	XY G ohm	
Gold			X.Y ohm	5%
Silver			0.XY ohm	10%
None				20%

**Figure 3:** Numerical values of different colors used in resistors

Given a resistor with red, orange, red and silver stripes you can see that the nominal resistance value should be 2.3K (2300) ohms. However, the silver stripe indicates that it is a 10% tolerance resistor and can have an actual value of 2070 to 2530 ohms.

**Multimeter:** A multimeter is a device used to measure voltage, resistance and current in electronics & electrical equipment. It is also used to test continuity between 2 points to verify if there are any breaks in circuit or line. There are two types of multimeter Analog & Digital-

- Analog has a needle style gauge
- Digital has an LCD display

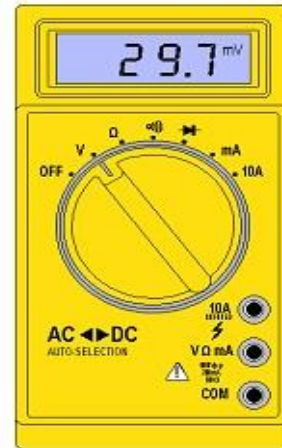
### Switched

Manually switch between ranges to get most accurate reading.



### Auto Range

Switches between ranges automatically for best reading.



Both of these styles work the same

## Meter leads

#### •Red meter lead

Is connected to Voltage/Resistance or amperage port  
Is considered the positive connection

#### •Probes

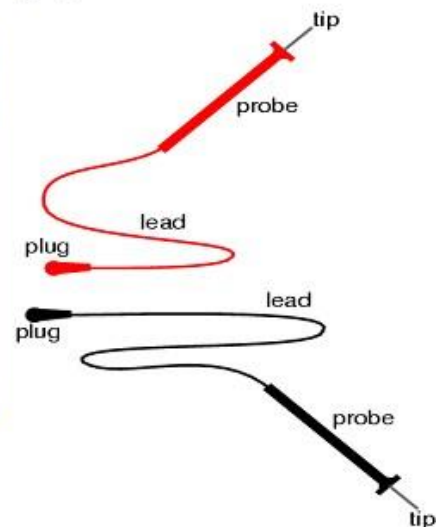
Are the handles used to hold tip on the tested connection

#### •Tips

Are at the end of the probe and provides a connection point

#### •Black meter lead

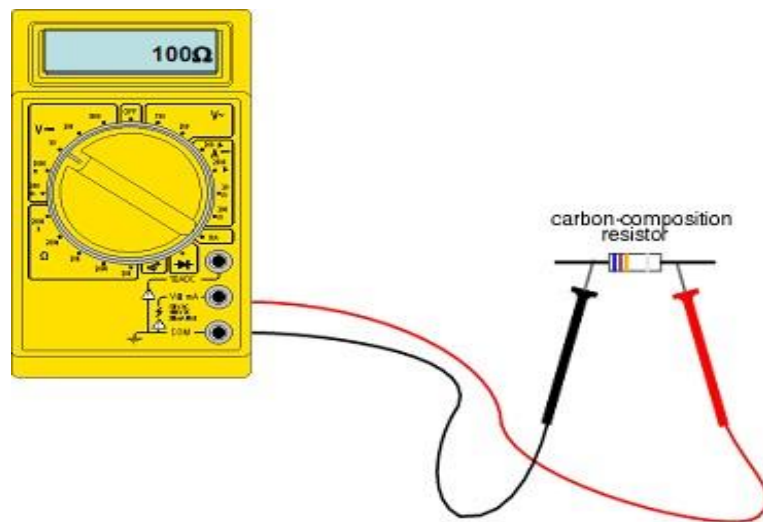
Is always connected to the common port  
Is considered the negative connection



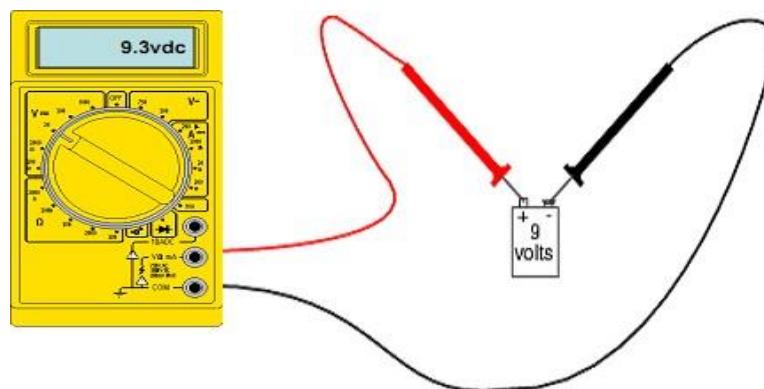
**Common DMM (Digital Multi meter symbol):**

$\sim$	AC Voltage	$\equiv$	Ground
$\equiv$	DC Voltage	$\text{--}  \text{--}$	Capacitor
Hz	Hertz	$\mu\text{F}$	MicroFarad
+	Positive	$\mu$	Micro
—	Negative	m	Milli
$\Omega$	Ohms	M	Mega
$\nabla$	Diode	K	Kilo
$\bullet \text{ )))}$	Audible Continuity	OL	Overload

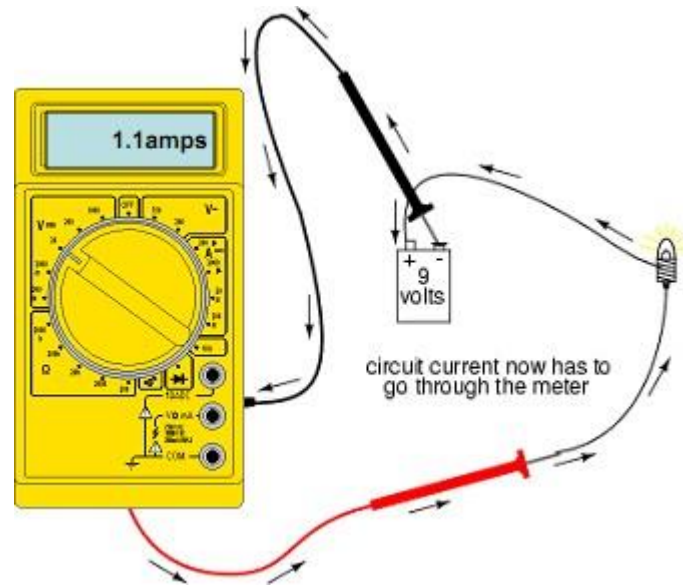
**Measuring resistance:**



**Measuring Voltage:**



### Measuring current:



**Breadboard:** A breadboard is a reusable solderless device used to build a (generally temporary) prototype of an electronic circuit and for experimenting with circuit designs. This is, in contrast, to stripboard (Veroboard) and similar prototyping printed circuit boards, which are used to build more permanent prototypes or one-offs, and cannot easily be reused.

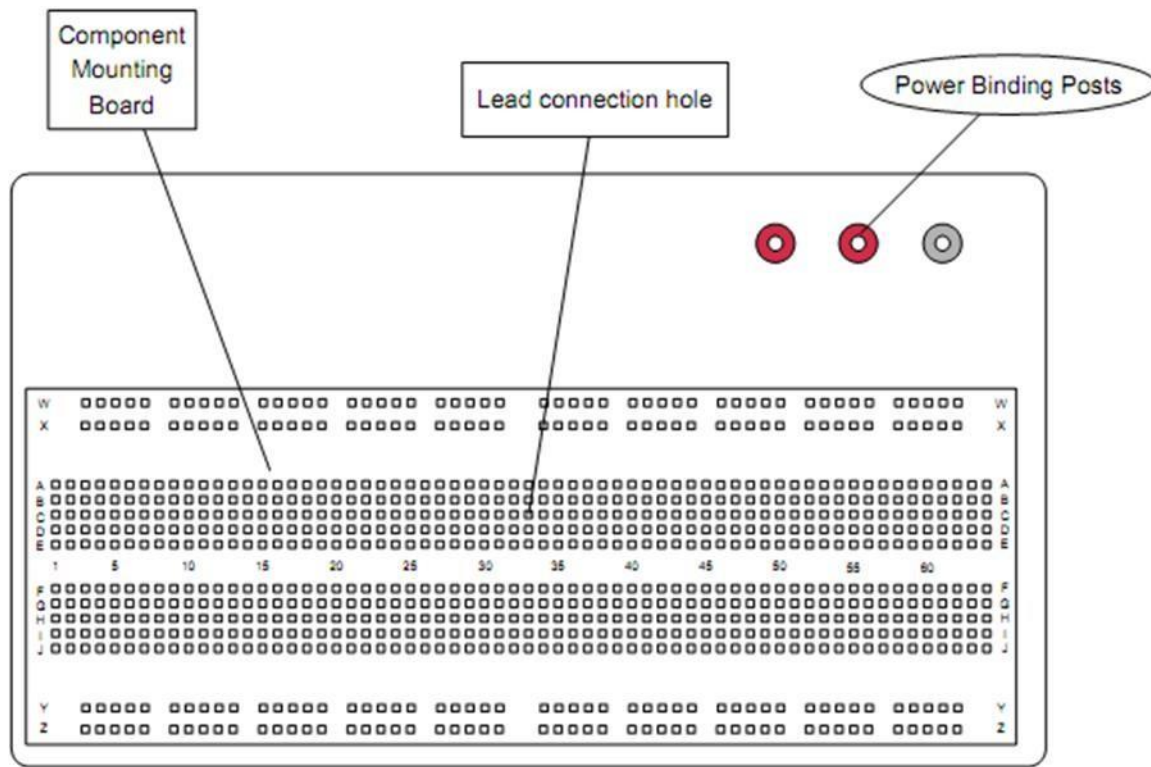


Figure 4: Breadboard



This type of board consists of several parts-

- The first part is a metal base plate. This plate is connected to the black (ground) binding post. This allows for some noise dampening if the circuit is built fairly close to the board.
- The second portion of the board is the binding post area. This part of the board is typically used to bring power supply leads onto the board. The black is typically ground and the two red posts can be used for other power (i.e. +/- 15VDC). Unscrewing the top of the post reveals a hole used for connecting a discrete wire. Pushing the stripped end of the wire in this hole and tightening down the cap will make a good electrical connection. The top of the post is hollow to accept a banana connector from a power supply.
- The third and most important part is the breadboard itself. This white plastic board contains a series of holes with metal connector strips underneath. This allows component leads to be pushed into the holes to make contact with other leads and wires. This breadboard area is broken up into two areas-
  - *Power buss strips:* rows W, X, Y and Z. These are used to supply power to a circuit at various points. These strips are usually jumpered to the binding posts by the user. These are joined together internally to form busses. For example, row W columns 3 thru 31 are joined together and row W column 34 thru 62 are joined to form another buss.
  - *Component area:* rows A-J. These holes are grouped in a set of 5 (column 1 rows A-E, column 1 rows F-J, etc.) for placing components and making connections. The layout of the connections can be seen in the figure below. The lines connecting the holes represent the connections made by the metal strips under the plastic.

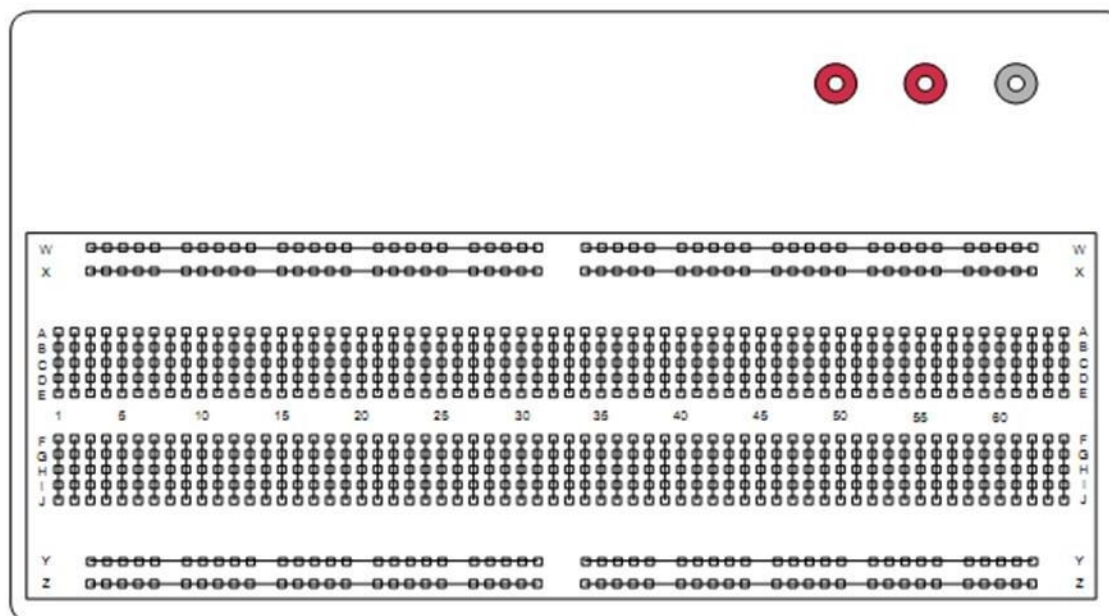


Figure 5: Connection patterns among the holes in a breadboard

**Electrical power supply:** Power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy.

**Pre-lab homework:**

1. Get some basic idea about electricity and voltage from books or the internet.

**Apparatus:**

1. Trainer Board
2. Voltmeter
3. Ammeter
4. AVO meter or Multi meter
5. DC source
6. Resistors

**Precautions:**

- ✓ When measuring voltage, the multimeter must be connected to the two points of a circuit in order to obtain the desired value. Be careful not to touch the bare probe tips together while measuring voltage, as this will create a short-circuit!
- ✓ Never read the value of resistance or perform a continuity test with a multimeter in a circuit that is energized.
- ✓ When measuring current, the multimeter must be connected to the circuit so that the electrons flow through the meter.
- ✓ Multimeters have practically no resistance between their leads. This is intended to allow electrons to flow through the meter with the least possible difficulty. If this were not the case, the meter would add extra resistance in the circuit, thereby affecting the current reading.

**Experimental Procedure and calculation:**

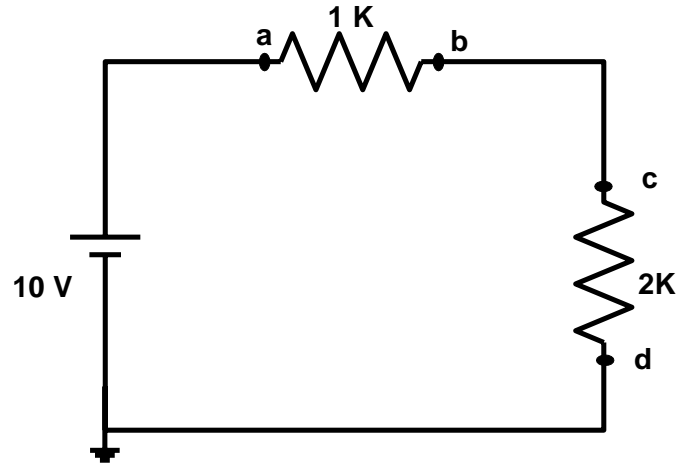
1. Calculate the values of the supplied resistors using the color code chart theoretically. Then measure the values using a multimeter and complete the following table:

**Table 1**

<b>Resistor</b>	<b>Value using color code chart</b>	<b>Value using multimeter</b>
R1		
R2		
R3		
R4		
R5		



- Construct the following circuit (Figure 6). Theoretically calculate  $R_T$  (total resistance),  $I$  (total Current),  $V_{ab}$ ,  $V_{cd}$ ,  $V_a$  and  $V_b$ . Again calculate the same quantities using the multimeter and complete the table (Table 3) provided below.



**Figure 6:** Circuit schematic to perform the 2nd step of the experimental procedure

**Table 2**

E	Theoretical Calculation						Multimeter readings				
	$R_T$	I	$V_{ab}$	$V_{cd}$	$V_a$	$V_b$	I	$V_{ab}$	$V_{cd}$	$V_a$	$V_b$
5 V											
10 V											

### Questions:

- Show the difference between your theoretical value & Multi meter value.
- Do you have differences in those values? If you have, then explain the reason.
- Why an ammeter can be damaged if it is connected in parallel to the Load resistor?