Experiment-1

Familiarisation with Resistor

A)Objectives:

- Explain the function and unit of Resistors
- Measure the value of a Resistor
- Measure the Tolerance of a Resistor
- Explain the types of Resistors

B)Theory:

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits.
Resistance of a conductor having length ‘l’, cross-sectional area ‘A’ whose resistivity is ‘ρ’ is

$$\mathbf{R} = \rho \frac{\mathbf{1}}{\mathbf{A}}$$

Types of Resistors

- Fixed resistors: Fixed resistors are by far the most widely used type of resistor. They are used in electronics circuits to set the right conditions in a circuit. Their values are determined during the design phase of the circuit, and they should never need to be changed to "adjust" the circuit. There are many different types of resistor which can be used in different circumstances and these different types of resistor are described in further detail below.

- Variable resistors: These resistors consist of a fixed resistor element and a slider which taps onto the main resistor element. This gives three connections to the component: two connected to the fixed element, and the third is the slider. In this way the component acts as a variable potential divider if all three connections are used. It is possible to connect to the slider and one end to provide a resistor with variable resistance.

Carbon Film Resistors

- Most general purpose ,cheap resistor
- Tolerance of Resistance value is usually +/- 5%
- Power ratings of 1/8 W ,1/4 W and ½ W are usually used
- The disadvantage of using carbon film resistor is that they generally tend to be electrically noisy

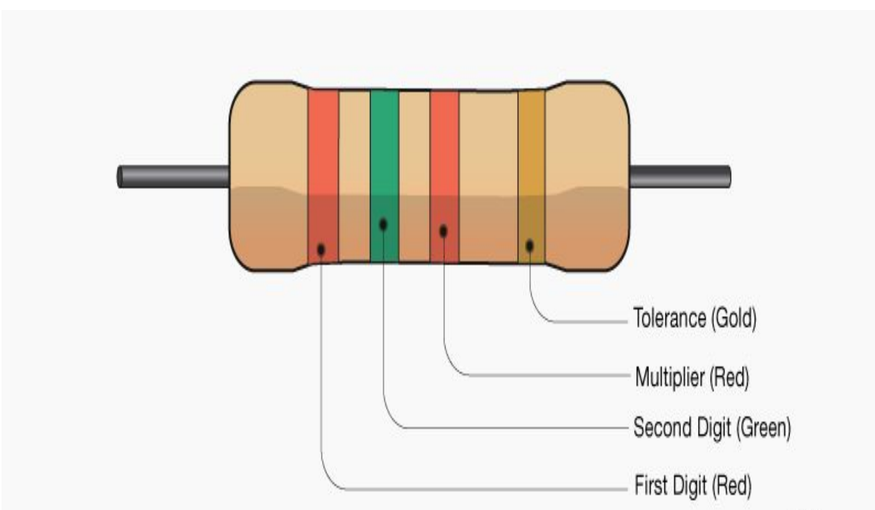
Metal Film Resistor

- Used when higher tolerance is needed , i.e. more value.
- They have about +/- 0.05% tolerance

Wire Wound Resistors

- A wire wound resistor is made of metal resistance wire, and because of this they can be manufactured to precise values
- Also, high wattage resistors can be made by thick wire material
- Wire wound resistors in a ceramic case are called as ceramic resistors
- Wire wound resistors in a ceramic case are called as ceramic resistors

<u>Colour Coding in Resistors</u> :



The resistance value, tolerance, and wattage rating are generally printed onto the body of the resistor as numbers or letters when the resistor's body is big enough to read the print, such as large power resistors. But when the resistor is small such as a 1/4 watt carbon or film type, these specifications must be shown in some other manner as the print would be too small to read.

So to overcome this, small resistors use coloured painted bands to indicate both their resistive value and their tolerance with the physical size of the resistor indicating its wattage rating.

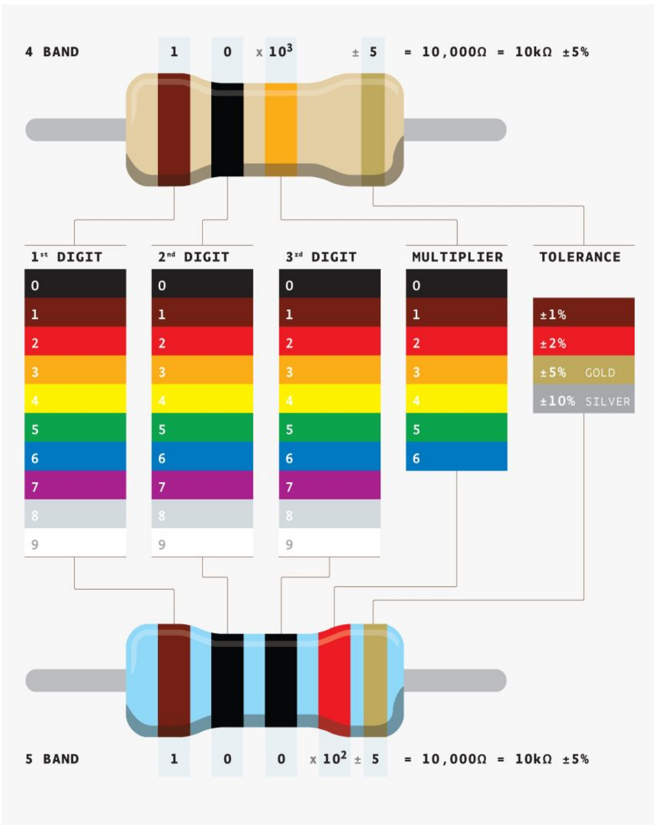
These coloured painted bands produce a system of identification generally known as a Resistors Colour Code.

Tolerance

- The last band denotes tolerance . So the value of the 4 band resistor is +/- 10% while for the 5 band resistor it is +/- 1%.
- Tolerance of a Resistor is also an important property to consider .
- A 100 ohm resistor with a 10 % tolerance can mean its value can be any fixed value between 90 to 110 Ohms.
- A 120 Ohm resistor with a 10 % tolerance can mean its value can be any fixed value between 108 and 132 Ohms.
- So there is some overlap between 100 Ohm and 120 Ohm resistance in terms of its limits

C)Procedure :

Reading Values of Fixed Resistors :



Step-1 : If your resistor has four color bands ,turn the resistor so that the gold or silver band is on the right hand side or the end with more bands should point left.

Step-2 : The first band is now on the left hand side. This represents the first digit .Based on the color, make a note of the digit.

Step-3 : The second band represents the second digit. The colors represent the same numbers as did the first digit .

Step-4 : The third band divulges how many zeros to add/divide to the first two numbers –for a 4 band resistor.

Step-5 : The third band denotes the 3rd digit – for a 5 band Resistor.

The “left-hand” or the most significant coloured band is the band which is nearest to a connecting lead with the colour coded bands being read from left-to-right as follows:

Digit, Digit, Multiplier = Colour, Colour x 10^(colour) in Ohm’s (Ω)

D)Tables:

Colour	Value	Multiplier (in Ω)	Tolerance	Colour Band
Black	0	1		
Brown	1	10	± 1%	
Red	2	100	± 2%	
Orange	3	1000		
Yellow	4	10000		
Green	5	100000	±0.5%	
Blue	6	1000000	± 0.25%	
Violet	7	10000000	± 1%	
Grey	8		± 0.05%	
White	9			
Gold	-		± 5%	
Silver	-		± 10%	
None	-		± 20%	

E)Discussion

Aside from using devices like multimeters , the resistance value can be computed using the colour code on the resistor . There are small differences between the colour coded value and the one measured via a multimeter , however these can be neglected . There are broad classifications of resistor , fixed and variable, metal , carbon etc . Also resistor is an electrical component in a circuit that obeys Ohm’s Law and thus the V-I characteristics of R is a straight line passing through the origin . Thus ,resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses

RESISTOR	VALUE
1. 	Value : $47 \times 10^3\ \Omega$ Tolerance : 5%
2. 	Value : $5.2\ \Omega$ Tolerance : 10%
3. 	Value : $97\ \Omega$ Tolerance : 20%
4. 	Value : $3.3 \times 10^3\ \Omega$ Tolerance : 5%
5. 	Value : $1.58\ \Omega$ Tolerance : 2%
6. 	Value : $6.15\ \Omega$ Tolerance : 0.25%

F)Conclusion :

Hence , a resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element which opposes flow of current in the circuit. Thus , it is clear by using the above table we can find out the values and tolerances of resistors , also so as to remember the colour code table we can use “BBROY of Great Britain Has a Very Good Wife” .

<u>Familiarisation with Capacitor</u>

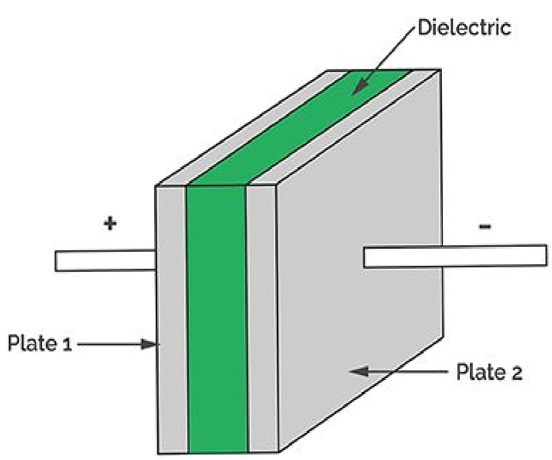
A)Objective

- Provide a definition of capacitor and name its units
- Explain how a capacitor can be constructed to give a particular value of capacitance
- Explain why a capacitor has maximum working voltage
- Determine experimentally the energy stored in a capacitor
- Identify the value and type of capacitor
- Identify the polarity of terminals

B) Theory

The capacitor is a two terminal electrical conductor and that is separated by an insulator. These terminals store electric energy when they are connected to a power source. One terminal stores positive energy and the other terminal stores negative charge. Charging and discharging of the capacitor can be defined as, when electrical energy is added to a capacitor is called charging whereas releasing the energy from a capacitor is called discharging.

<u>Construction of Capacitor</u> :



The simplest form of a capacitor is a " parallel plate capacitor" and its construction can be done by two metal plates that are placed parallel to each other at some distance.

If a voltage source is connected across a capacitor where the +ve (positive terminal) is connected to the positive terminal of a capacitor and negative terminal is connected to –ve (negative terminal) of the capacitor. Then, the energy which is stored in the capacitor is directly proportional to the applied voltage.

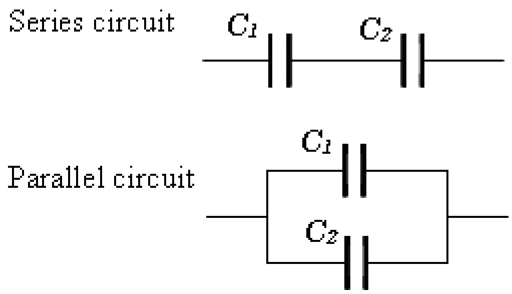
<u>Capacitance</u>

A capacitor is so called because it has the capacity to store charge- just like a beaker storing a liquid. Capacitors are marked with a value which indicates their capacitance – their ability to store charge . Capacitance can be thought of as the "electrical capacity" of that body. It is measured in Farads.

A static description of the way a capacitor behaves would be to say $Q=C\times V$, where Q is the total charge, C is a measure of how big the capacitor is and V is the voltage across it.

A dynamic description ,i.e. one that changes with time would be to say $I=C\times dV/dt$. This is just the time derivative of the static description .C is constant wrt time, I is the rate at which charge flows . This essentially says – the bigger the current , the faster the capacitor’s voltage changes.

Capacitors in Combinations :



In Series,

For n capacitors in series,

$$1/C_{eq} = 1/C_1 + 1/C_2 + \dots\dots + 1/C_n$$

In Parallel,

For n capacitors in parallel,

$$C_{eq} = C_1 + C_2 + \dots\dots + C_n$$

Types of Capacitors

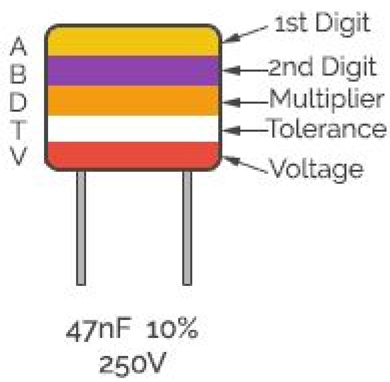
Types of Capacitor

- ➢ Unpolarized (They don't have positive and negative electrode) :
  - Ceramic
  - Multilayer
  - Polystyrene Film
  - Polyester Film
  - Polypropylene
  - Mica

- ➢ Polarized (They have positive and negative electrode) :
  - Electrolytic
  - Tantalum
  - Super

Name	Image	Description
Ceramic		A ceramic capacitor is a fixed-value capacitor where the ceramic material acts as the dielectric.. The capacitance of ceramic capacitors is usually in the range of picofarads to few microfarads (less than 10μF). They are non-polarised type capacitors and hence can be used in both DC as well as AC circuits.
Electrolytic Capacitor		An electrolytic capacitor is a polarized capacitor whose anode or positive plate is made of a metal that forms an insulating oxide layer through anodization. This oxide layer acts as the dielectric of the capacitor.It is very easy to find the values of electrolytic capacitors because they are clearly printed with their capacitance and voltage rating.
Tantalum Capacitor		Tantalum bead capacitors are polarized and have low voltage ratings like electrolytic capacitors . Usually , the “+” symbol is used to show the positive component lead . Modern tantalum bead capacitors are printed with their capacitance voltage and polarity in full. However older ones use a color – code systems which has two stripes (for the two digits) and a spot of color for the number of zeros to give the value in uF.

Un-polarized Capacitors — Capacitor Number Code

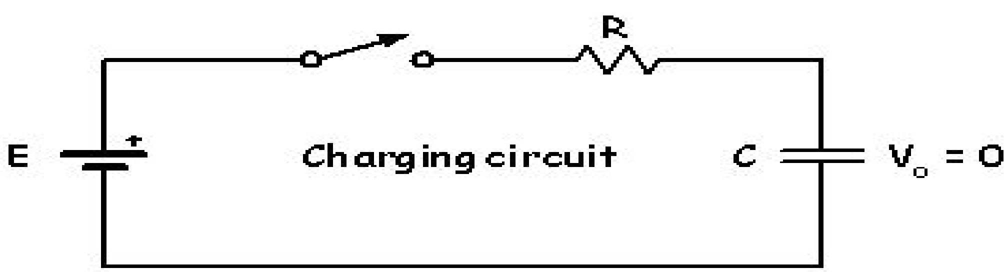


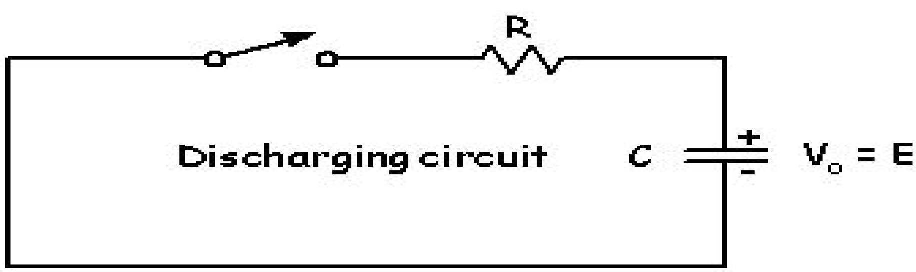
A number code is often used on small capacitors where printing is difficult: The 1st number is the 1st digit, the 2nd number is the 2nd digit, the 3rd number is the number of zeros to give the capacitance in pF. Ignore any letters - they just indicate tolerance and voltage rating. For example: 102 means 1000pF (not 102pF!) For example: 472J means 4700pF (J means 5% tolerance).
The above figure shows the colour coding in capacitors.

Function of Capacitor

Its function is to store the electrical energy and give this energy again to the circuit when necessary. In other words, it charges and discharges the electric charge stored in it. Besides this, the functions of a capacitor are as follows , it blocks the flow of DC and permits the flow of AC, it is used for coupling of the two sections, it bypasses (grounds) the unwanted frequencies , it feeds the desired signal to any section, it is used for phase shifting, it is also used for creating a delay in time, it is also used for filtration,especially in removing ripples from rectified waveform, it is used to get tuned frequency, it is used as a motor starter, it is also used in conjunction with a resistor to filter ripples in a rectifier circuit.

Charging and Discharging





Charging of Capacitor

When a battery is connected to a series resistor and capacitor, the initial current is high as the battery transports charge from one plate of the capacitor to the other. The charging current asymptotically approaches zero as the capacitor becomes charged up to the battery voltage. Charging the capacitor stores energy in the electric field between the capacitor plates. The rate of charging is typically described in terms of a time constant RC.
The plate on the capacitor that attaches to the negative terminal of the battery accepts electrons that the battery is producing .The plate on the capacitor that attaches to the positive terminal of the battery loses electrons to the battery. Once it’s charged , the capacitor has the same voltage as the battery.

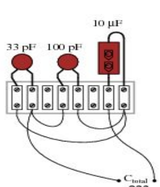
Discharging of Capacitor

If you then remove the battery and replace it with a wire , current will flow from one plate of the capacitor to the other. The bulb will light initially and then dim as the capacitor discharges , until it is completely out.

C)Discussion :
The capacitor is a component which has the ability or “capacity” to store energy in the form of an electrical charge producing a potential difference (Static Voltage) across its plates, much like a small rechargeable battery.
There are many different kinds of capacitors available from very small capacitor beads used in resonance circuits to large power factor correction capacitors, but they all do the same thing, they store charge.
When the capacitor is discharged through a resistor, the voltage across the capacitor and the charge on the capacitor decreases exponentially. When the capacitor is charged through a resistor, the voltage exponentially rises.

1.Two 33 μF capacitors are connected in series with each other. What will their combined capacitance be in Farads?
Ans)16.5μF

2. Calculate the total capacitance in this collection of capacitors, as measured between the two wires:
Calculate total capacitance given the values of inductors C1, C2, and C3



Ans)132.998pF

3.A 10μF capacitor is charged to a voltage of 20 volts.How many coulombs of electric charge are stored in this capacitor?
Ans)200μF of charge

4. Two 470μF capacitors connected in series are subjected to a total applied voltage that changes at a rate of 200 volts per sec. How much current will there be through these capacitors?
A)47mA

5. Two capacitors 470μF capacitors connected in parallel are subjected to a total applied voltage that changes at a rate of 200 volts per sec.How much total current will there be through these capacitors?
A)188mA

D)Conclusion :
Thus we have defined what a capacitor and capacitance is and described about the different types of capacitors,and thus described about charging and discharging of capacitors.

Familiarisation with Inductor

A)Objective :

- Explain Function of Inductor
- Explain the factors influencing inductance

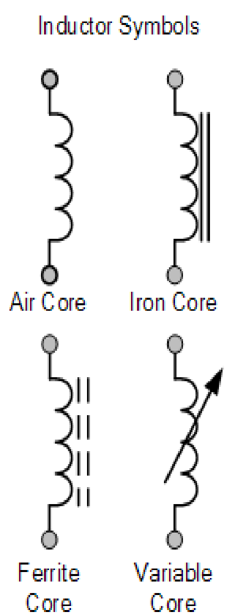
B)Theory:
An inductor, also called a coil, choke, or reactor, is a passive two-terminal electrical component that stores energy in a magnetic field when electric current flows through it. An inductor typically consists of an insulated wire wound into a coil around a core. It is similar to a capacitor in the following ways:

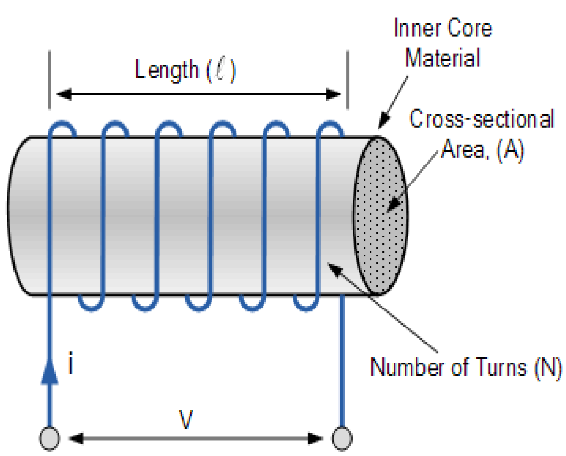
- Rate of change of voltage in a capacitor depends upon the current through it .
- Rate of change of current in an inductor depends upon the voltage applied across it,
- Like capacitive current , inductive current is not simply proportional to voltage
- Unlike the situation in a resistor, the power associated with inductive current (V times I) is not turned into heat but is stored as energy in the inductor’s magnetic field.

The following are main functions of an Inductor :

- In an electronic circuit, the resistor is used to control the amount of current that flows through a conductor.
- Mother device that controls the current is the inductor .
- However unlike the resistor that affects the current uniformly at all times, the inductor only affects currents when they are changing in value.

Inductance :





When the current flowing through an inductor changes, the time-varying magnetic field induces an electromotive force (e.m.f.) (voltage) in the conductor, described by Faraday's law of induction. According to Lenz's law, the induced voltage has a polarity (direction) which opposes the change in current that created it. As a result, inductors oppose any changes in current through them. An inductor is characterized by its inductance, which is the ratio of the voltage to the rate of change of current. In the International System of Units (SI), the unit of inductance is the henry (H).The amount of inductance in henries a coil has, is determined by the following factors -

- No of turns of wire wound around the coil
- Cross sectional area of the coil
- The material type of the coil
- The Length of the coil

Equation of an Inductor

V= L* dI / dt
L- is the inductance and is measured in henry.
Putting a voltage across an inductor causes the current to rise as a ramp , 1 volt across 1 henry produces a current that increases at 1 amp per second

Inductive Kick

An Inductive is capable of producing a momentary voltage that is much higher than the voltage of the power source that supplied the current to create its magnetic field . This temporary voltage is called an inductive kick.

C)Discussion :

1)If the number of turns of coil around an inductor is increased (doubles), how will the inductance change ?
A)When the number of turns in a coil is doubled, coefficient of self-inductance of the coil becomes 4 times.This is because self inductance is directly proportional to the square of the number of turns in a coil.

2)If the distance between the turns of coil around an inductor is increased (doubles), how will the inductance change ?
A)Long gap between the turns means more lengthy coil and it means less inductance. On the other hand if you fix the length then a long gap means less number of turns and it causes to decrease the inductance. In fact, inductance is inversely proportional to coil length and directly proportional to the square of the number of turns in the coil. So, the inductance reduces to half its normal value

3)If the diameter of the coil around an inductor is increased(doubles),how will the inductance change?
A)The inductance also doubles as inductance is inversely proportional to coil length and directly proportional to the square of the number of turns in the coil.

Ohm's Law

A)Objective :

- Explain Ohm's Law
- Explain Ohm's Law for Resistance in series
- Explain Ohm's Law for Resistance in parallel
- Explain Non Ohmic Device
- Measure and confirm Ohm's Law

B)Apparatus :

Apparatus	Type	Range	Quantity
Voltage Source	DC	0 - 30 V	1
Resistor		1 kΩ – 100 kΩ	2
Ammeter	Moving Coil	0 - 20 A	1
Voltmeter	Moving Coil	0 - 30 V	1
Diode			1

C)Theory :

Ohm's Law :

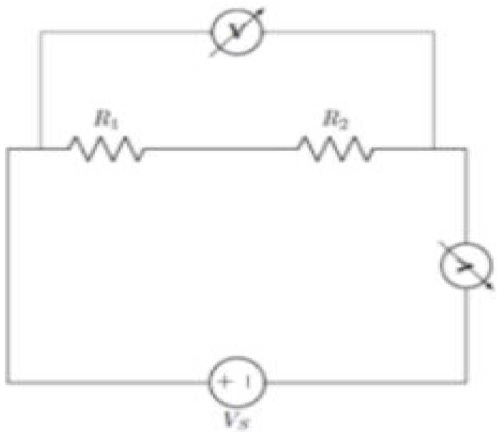
1. The law states that the current through a conductor between two points is directly proportional to the voltage across the two points. Such a conductor is characterized by its 'Resistance' – R measured in Ohms.

2. V = I * R

- V is the Voltage in Volts across the conductor.
- I is the current in Amperes through the conductor.
- Voltage(V) is directly proportional to current i.e V = I * R.
- Resistance(R) is inversely proportional to current(I) i.e I = V/R.

<u>Ohm's Law with Resistance in Series:</u>

Series circuits are sometimes called current-coupled or daisy chain-coupled. The current in series circuit goes through every component in the circuit. Therefore, all of the components in a series connection carry the same current. There is only one path in a series circuit in which the current can flow.



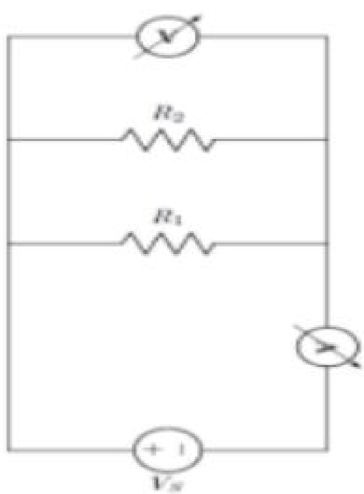
Voltage : $V = V_1 + V_2 + V_3$

Current : $I_1 = I_2 = I_3 = I$

Ohm's Law : $V = I \times R_{eq}$
Thus,
Resistance : $R_{eq} = R_1 + R_2 + R_3$

In a series circuit, the current through each of the resistors is the same, and the voltage across
the circuit is the sum of the voltages across each resistor.

<u>Ohm's Law with Resistance in Parallel:</u>
If two or more components are connected in parallel, they have the same potential difference (voltage) across their ends. The potential differences across the components are the same in magnitude, and they also have identical polarities. The same voltage is applicable to all circuit components connected in parallel. The total current is the sum of the currents through the individual components, in accordance with Kirchhoff's current law.



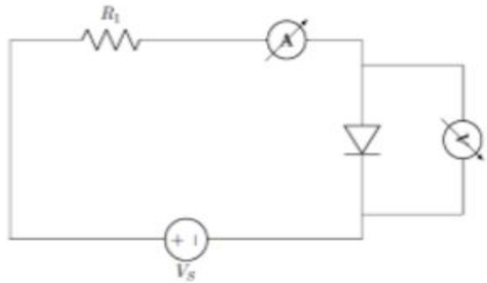
Voltage : $V_1 = V_2 = V_3 = V$

Current : $I = I_1 + I_2 + I_3$

Thus,
Resistance : $1/R_{eq} = 1/R_1 + 1/R_2 + 1/R_3$
In a parallel circuit, the voltage across each of the resistors is the same, and the total current
is the sum of the currents through each resistor.

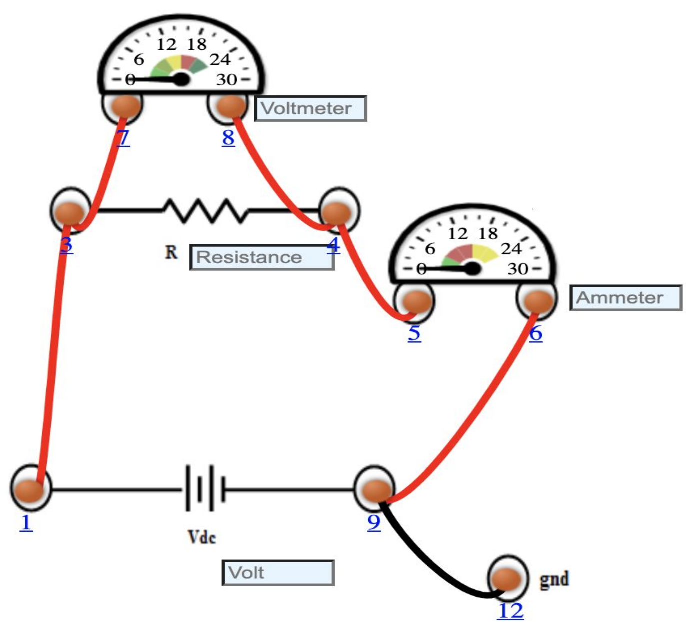
<u>Non-ohmic Device (Diode):</u>
A Non ohmic device is a device that does not obey Ohm's Law i.e. the resistance is not constant, but changes in a way that depends on the voltage across it. The device is said to be non-Ohmic. In this case V versus I graph is not a straight line, but has some curvy shape. Such devices do not have a constant value of resistance and the resistance is called dynamic

resistance because it is constantly changing. Examples of such devices are tungsten filament (bulb), diode, thermistor etc.

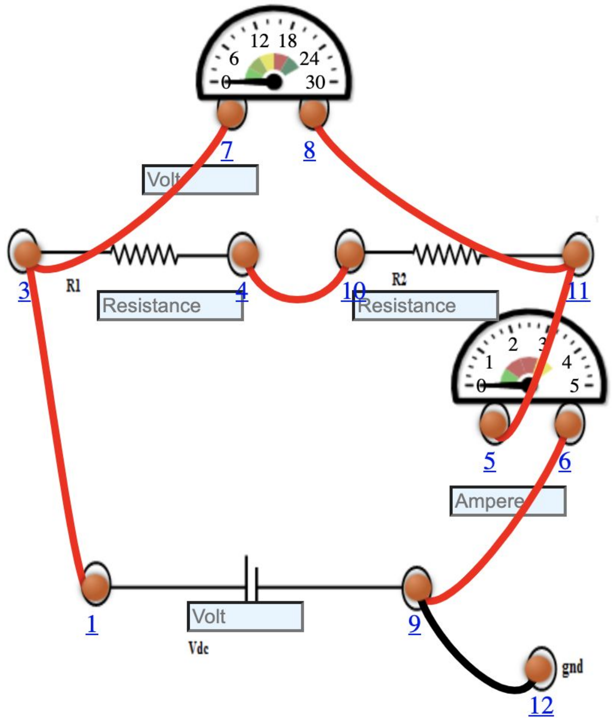


D)Circuit Diagram

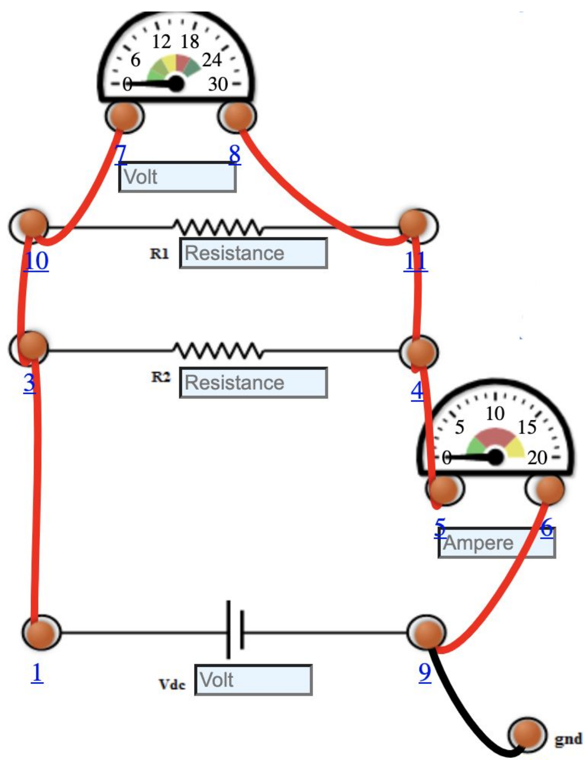
Ohm's Law



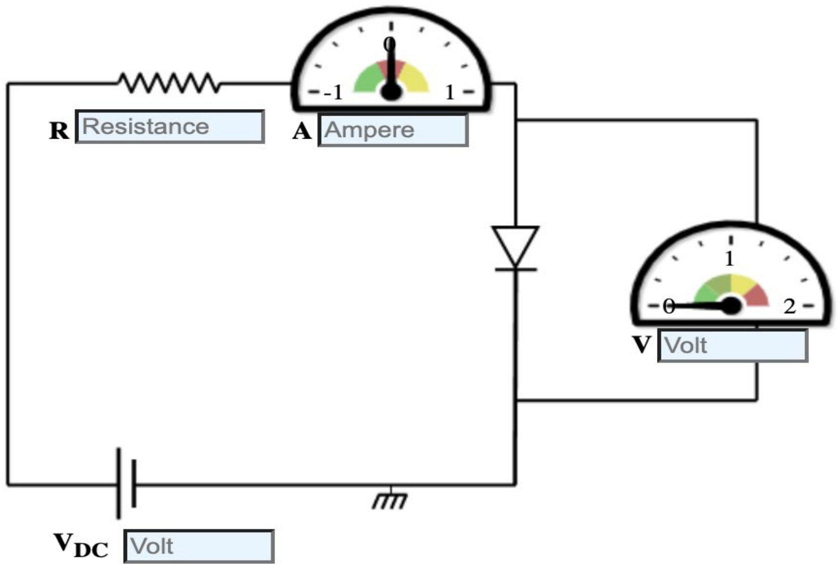
Ohm's Law Series :



Ohm's Law (Parallel):



Non - Ohmic Circuit :



E)Observations:

a)Ohm's Law:

Table-1

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	3	0.100
2	6	0.200
3	9	0.300
4	12	0.400
5	15	0.500
6	18	0.600
7	21	0.700
8	24	0.800
9	27	0.900
10	30	1.000

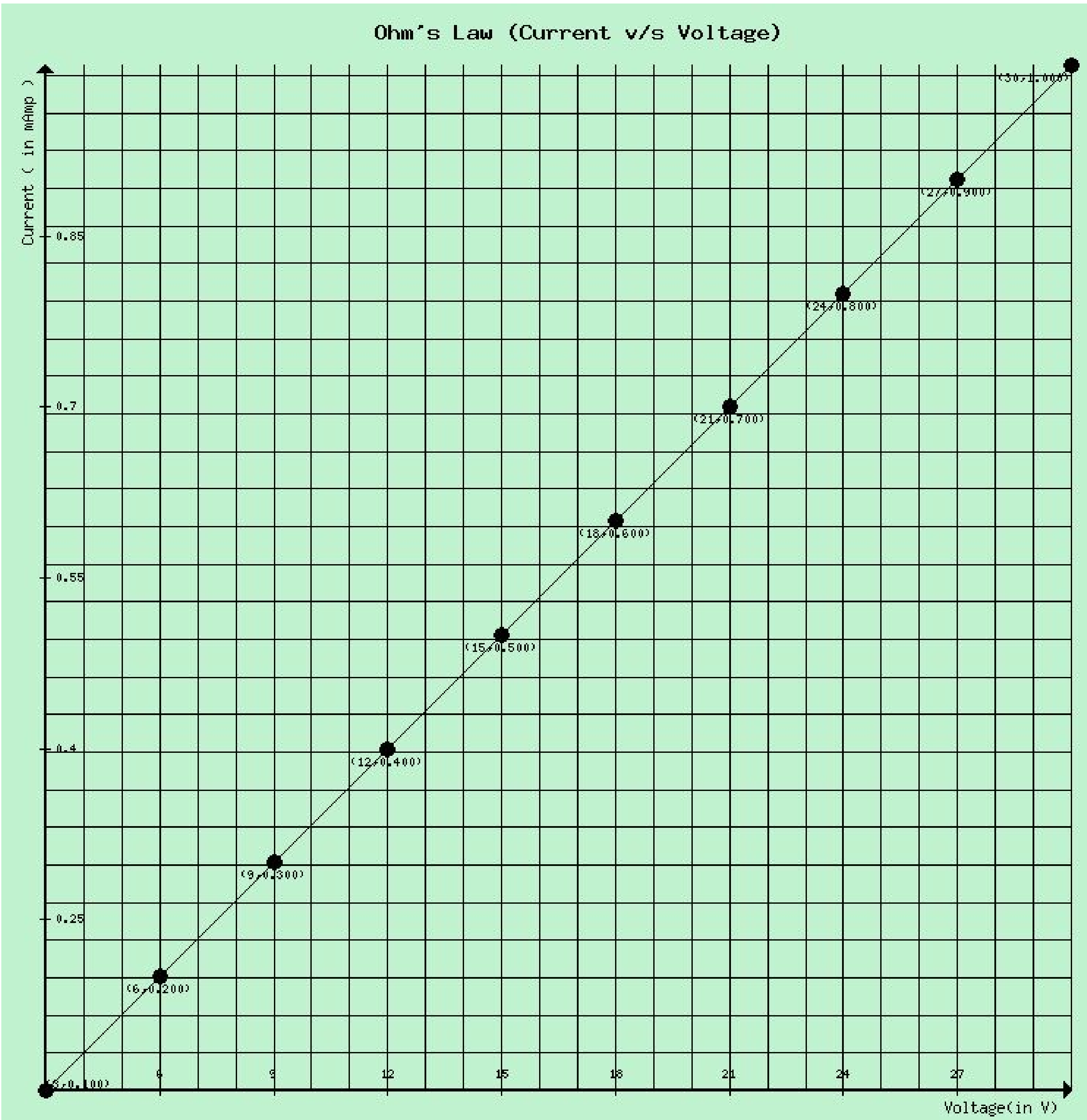
Resistance is 30 kΩ

Table-2

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	3	0.0429
2	6	0.0857
3	9	0.129
4	12	0.171
5	15	0.214
6	18	0.257
7	21	0.300
8	24	0.343
9	27	0.386
10	30	0.429

Resistance is 70kΩ

Graph (Table-1):

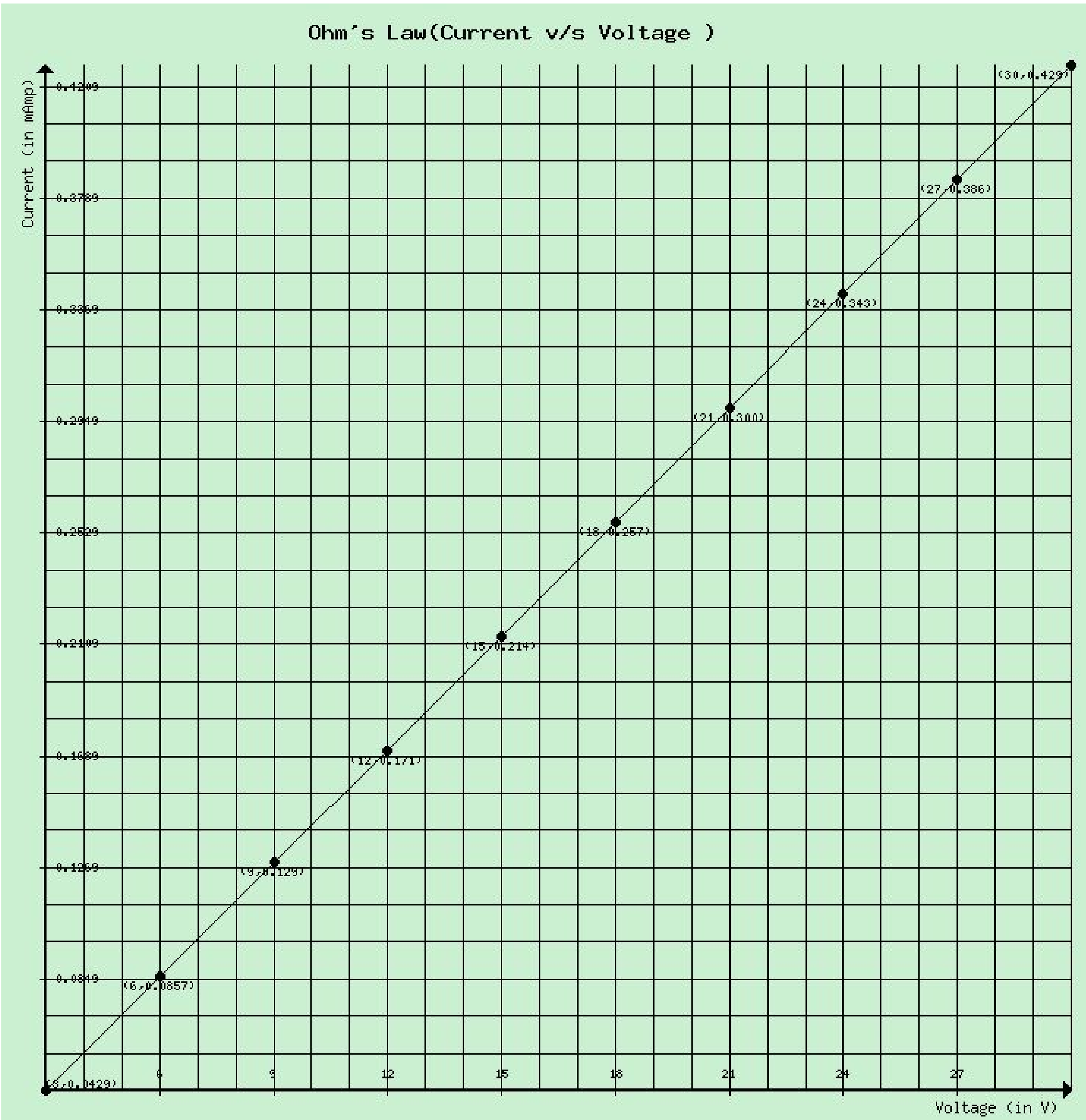


Scale:

X-axis(1 S.D = 1V)

Y-axis(1 S.D = 0.033 mAmp)

Graph(for Table-2):



Scale:
X-axis(1 S.D = 1V)
Y-axis(1 S.D = 0.0142 mAmp)

b) Ohm's Law (Series) :

Table-3

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	3	0.150
2	6	0.300
3	9	0.450
4	12	0.600
5	15	0.750
6	18	0.900
7	21	1.05
8	24	1.20
9	27	1.35
10	30	1.50

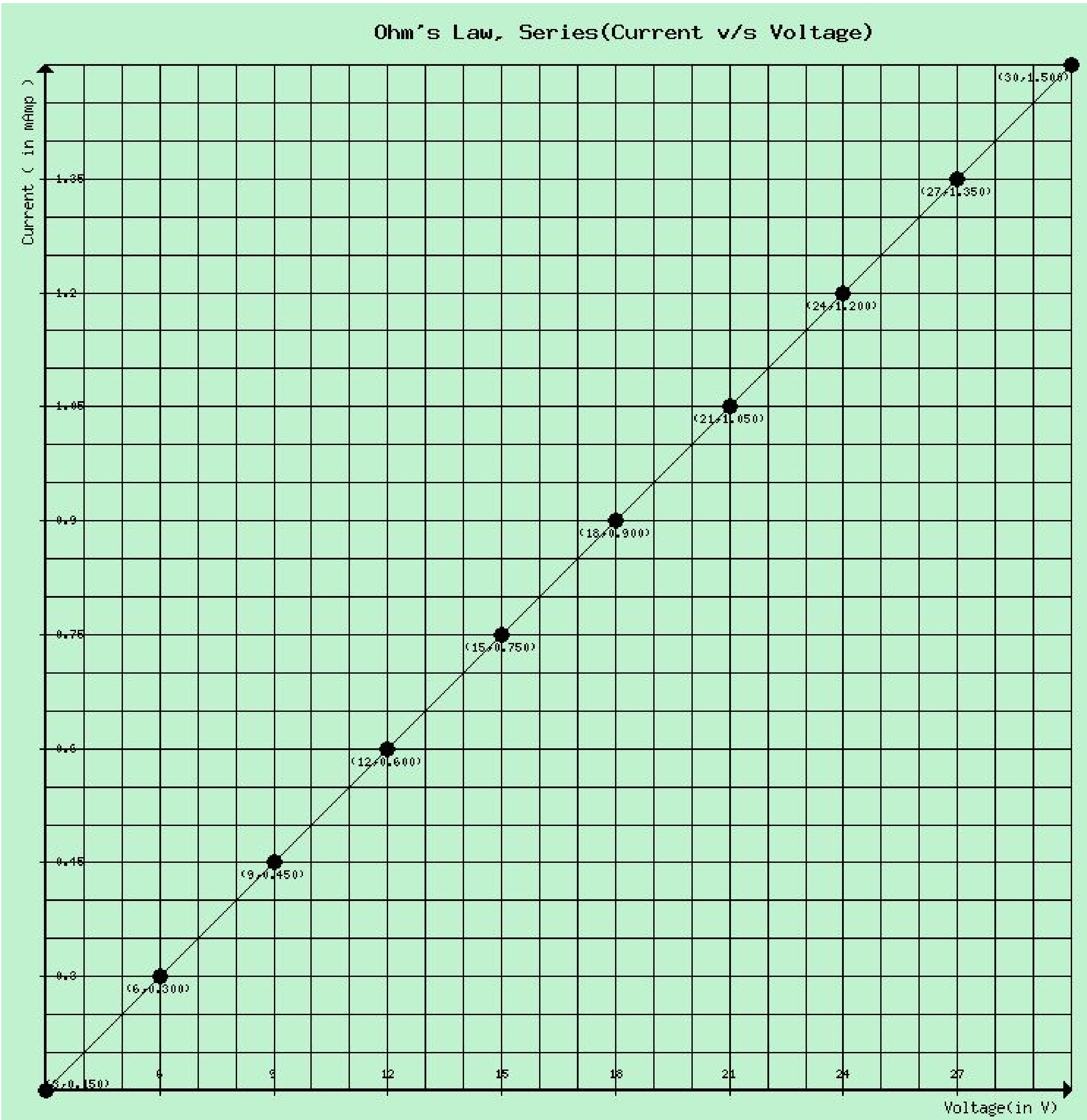
Resistance (R_1) = 10 kΩ
Resistance (R_2) = 10 kΩ
Equivalent Resistance (R_{eq}) = R_1 + R_2 = 20 kΩ

Table-4:

Serial No.	Voltage(Volt) V	Current(milliAmpere) mA
1	3	0.0750
2	6	0.150
3	9	0.225
4	12	0.300
5	15	0.375
6	18	0.450
7	21	0.525
8	24	0.600
9	27	0.675
10	30	0.750

Resistance (R_1) = 25 kΩ
Resistance (R_2) = 15 kΩ
Equivalent Resistance (R_{eq}) = R_1 + R_2 = 40 kΩ

Graph (for Table-3):

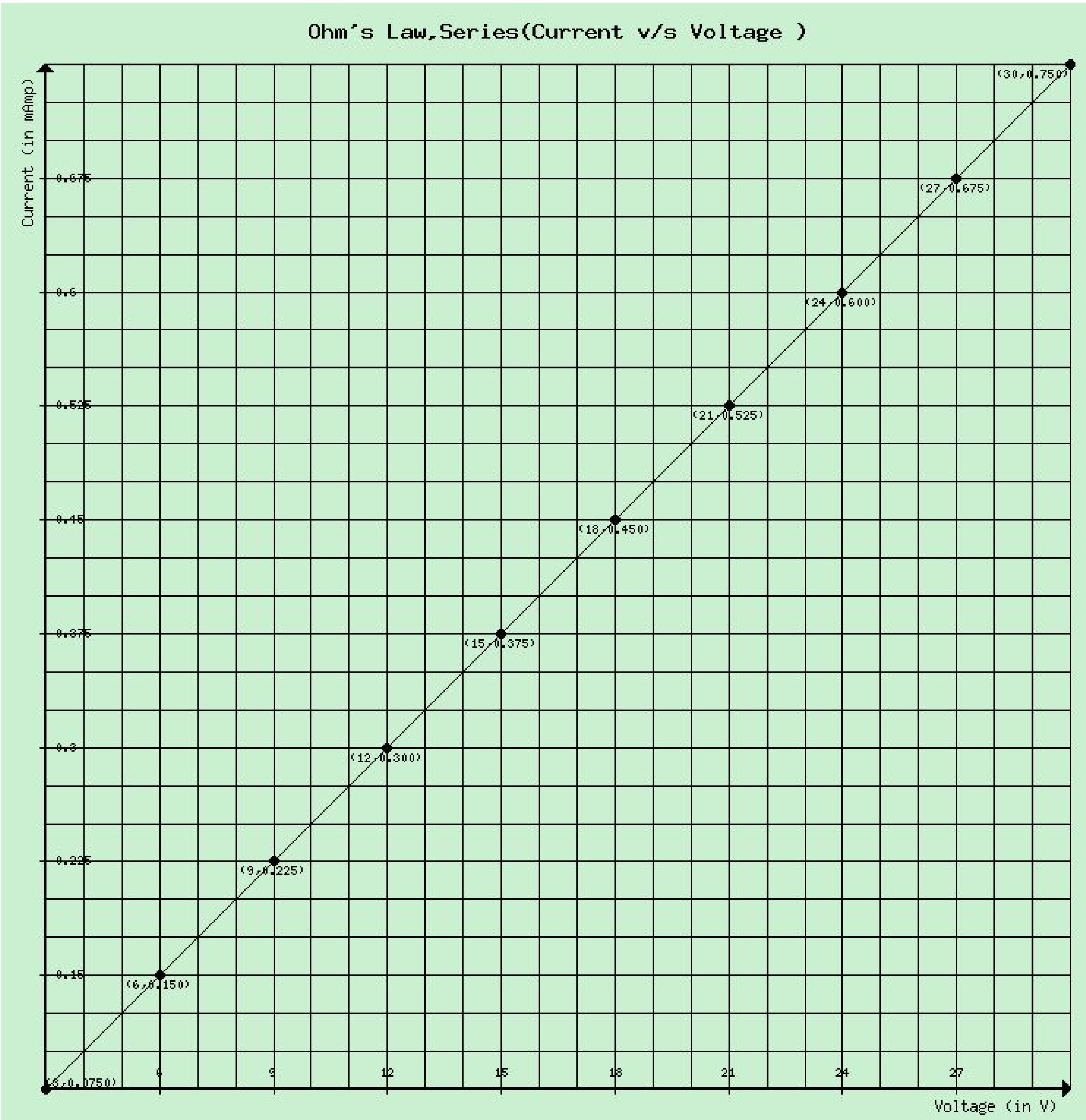


Scale:

X-axis(1 S.D = 1V)

Y-axis(1 S.D = 0.05 mAmp)

Graph (for Table-4):



Scale:
X-axis(1 S.D = 1V)
Y-axis(1 S.D = 0.075 mAmp)

c) Ohm's Law (Parallel) :

Table-5

Serial No.	Voltage (Volt) V	Current (milliAmpere) mA
1	3	3.0
2	6	6.0
3	9	9.0
4	12	12.0
5	15	15.0
6	18	18.0
7	21	21.0
8	24	24.0
9	27	27.0
10	30	30.0

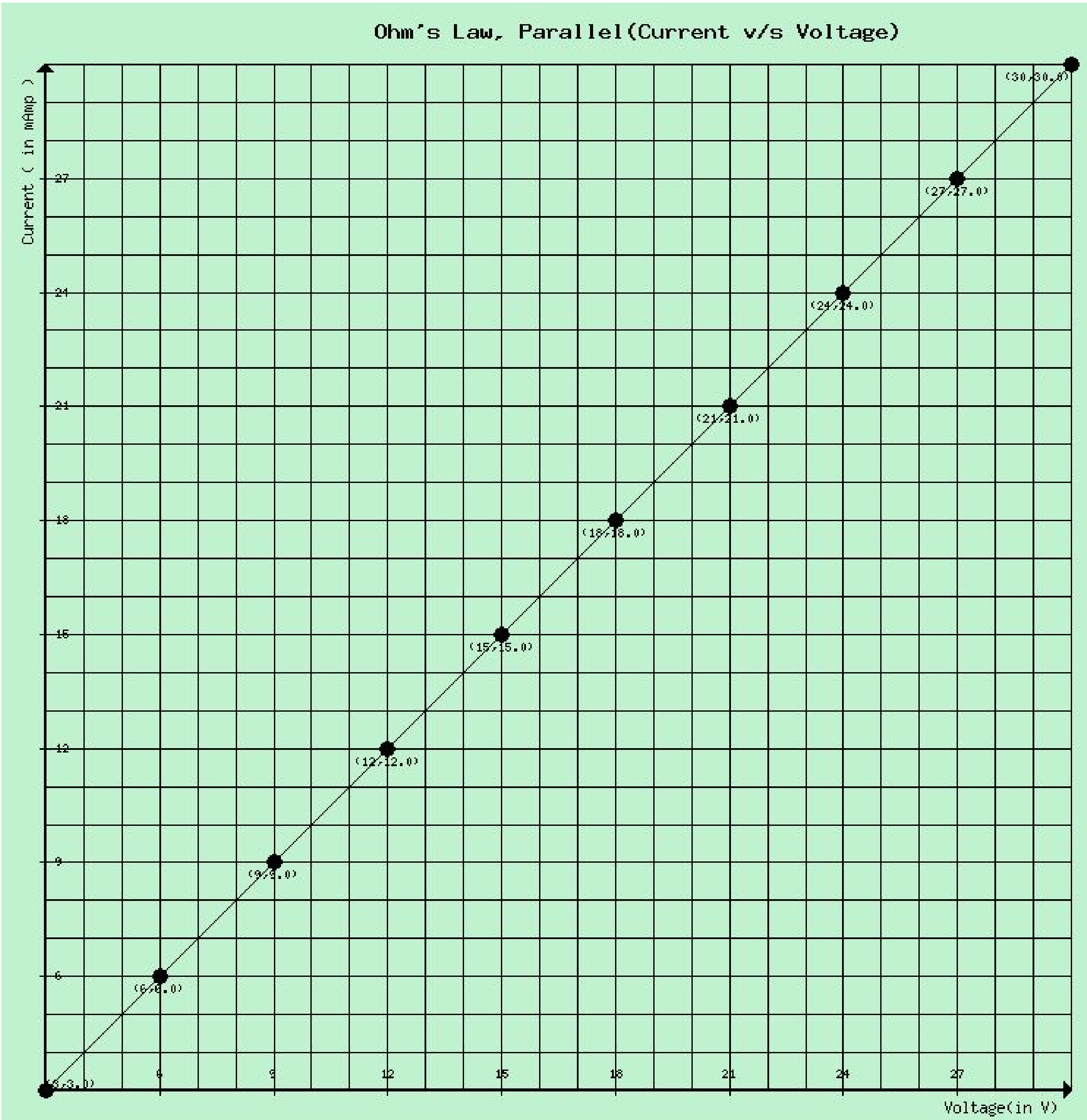
Resistance (R_1) = 1.1 kΩ
Resistance (R_2) = 11 kΩ
Equivalent Resistance (R_{eq}) = R_1 x R_2 / (R_1 + R_2) = 1 kΩ

Table-6

Serial No.	Voltage (Volt) V	Current (milliAmpere) mA
1	3	10.2
2	6	20.4
3	9	30.6
4	12	40.8
5	15	51.0
6	18	61.2
7	21	71.4
8	24	81.6
9	27	91.8
10	30	102

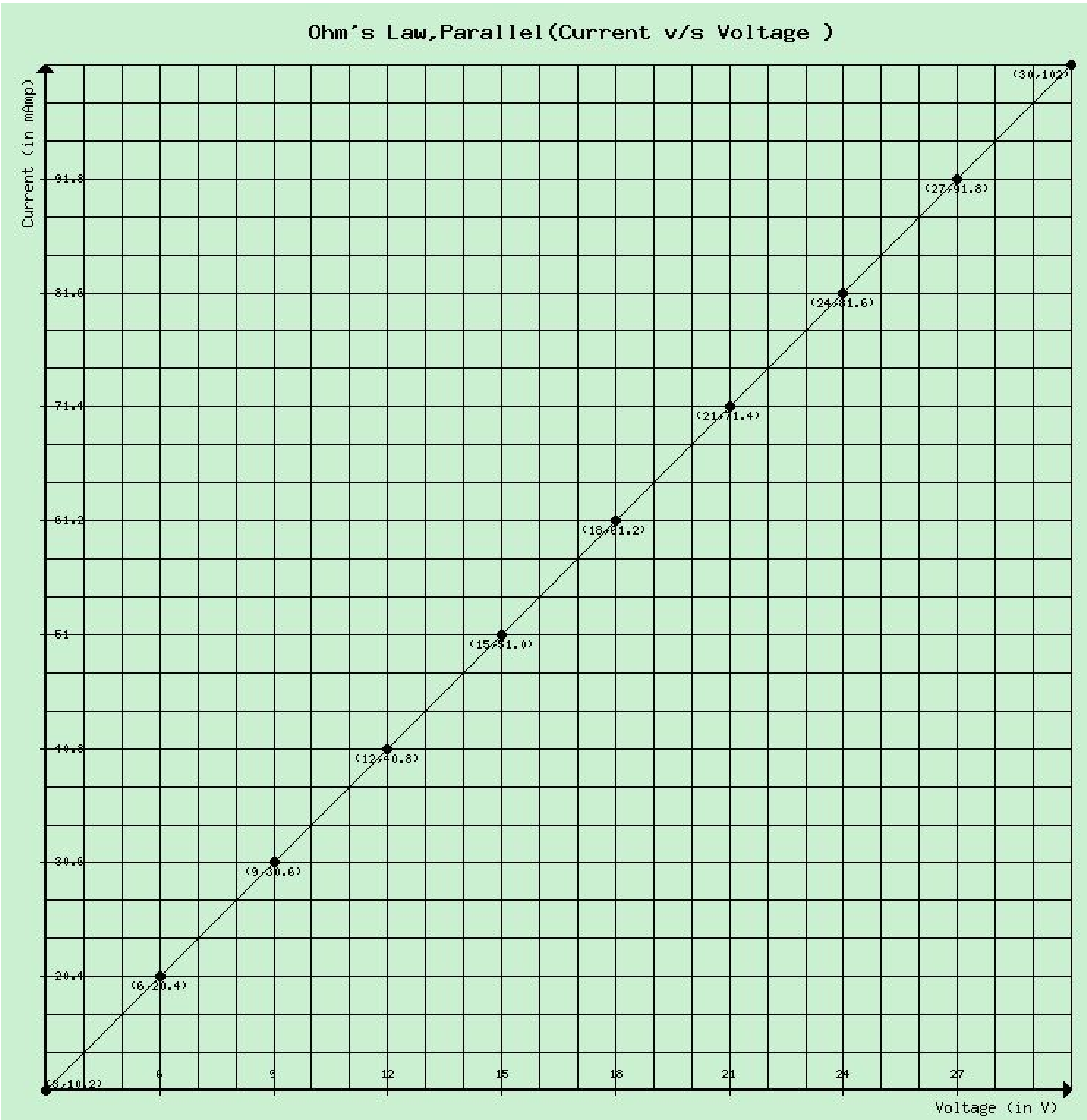
Resistance (R_1) = 0.3 kΩ
Resistance (R_2) = 15 kΩ
Equivalent Resistance (R_{eq}) = R_1 x R_2 / (R_1 + R_2) = 0.294 kΩ

Graph(for Table-5):



Scale:
X-axis(1 S.D = 1V)
Y-axis(1 S.D = 1 mAmp)

Graph(for Table-6):



Scale:
X-axis(1 S.D = 1V)
Y-axis(1 S.D = 3.2 mAmp)

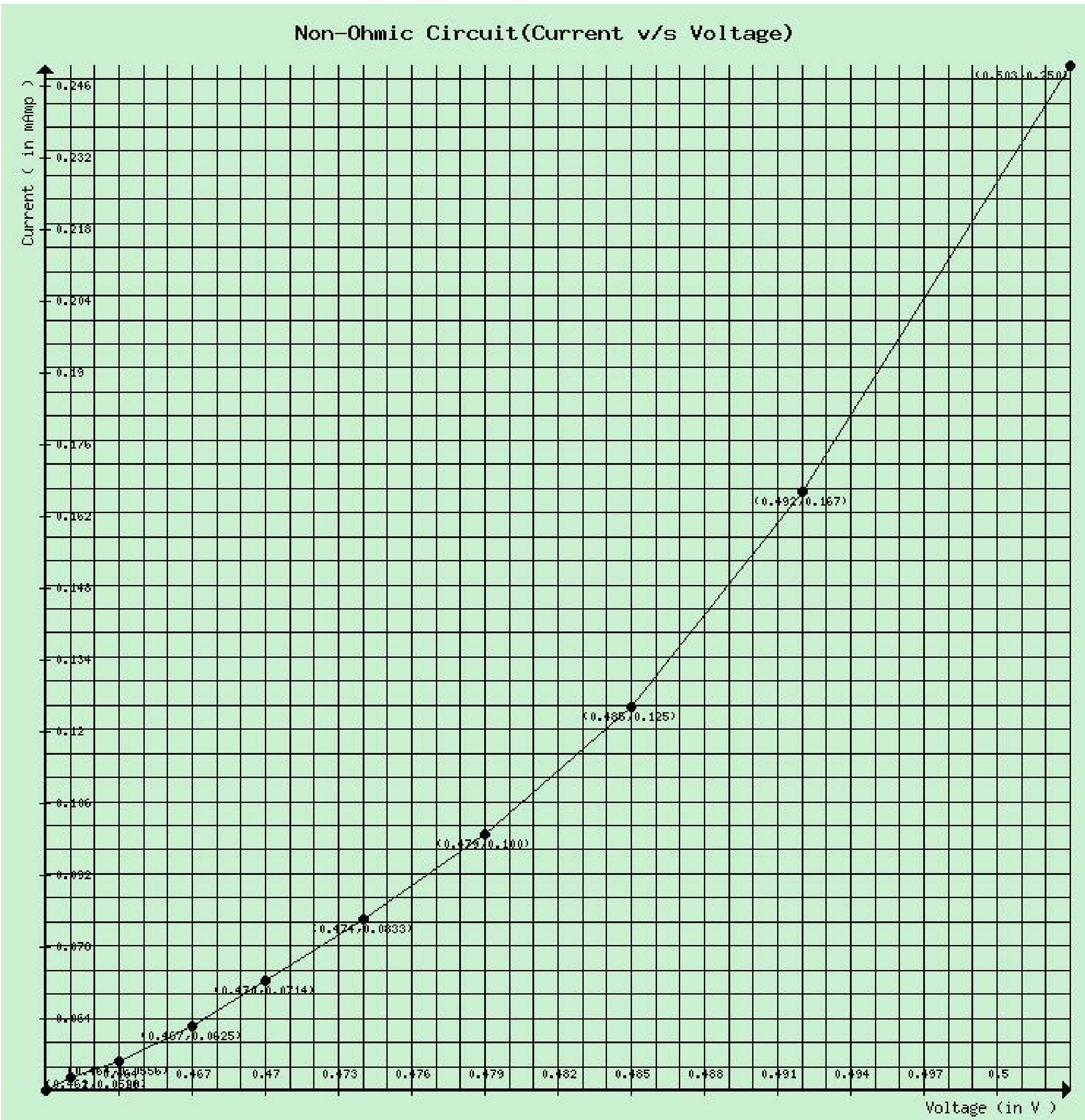
d) Non-Ohmic Circuit

Table-7

Serial No.	Voltage (Volt) V	Current (milliAmpere) mA	Resistance (kΩ)
1	0.503	0.250	20
2	0.492	0.167	30
3	0.485	0.125	40
4	0.479	0.100	50
5	0.474	0.0833	60
6	0.470	0.0714	70
7	0.467	0.0625	80
8	0.464	0.0556	90
9	0.462	0.0526	95
10	0.461	0.0500	100

DC Voltage : 5 Volt

Graph(for Table -7):



Scale:

X-axis(1 S.D = 0.001V)

Y-axis(1 S.D = 0.0047 mAmp)

F)Discussion :

- Ohm's Law is a very useful law but it only applies to devices that behave like resistors – i.e. – I is simply proportional to V.
- Ohm's Law describes one possible relationship between V and I in a component, but there are others, like
  - ➔ Capacitors (I proportional to rate of change of V)
  - ➔ Diodes (I flows in only 1 direction)
  - ➔ Thermistors (Temperature dependent resistors)

G)Conclusion :

A higher resistance would result in a straight line graph with a higher gradient when potential difference is graphed against current. Therefore a lower resistance would result in a straight line graph with a lower gradient.Resistance is measured in ohms (Ω).

Ohm’s law states that voltage is directly proportional to current, provided that the temperature remains constant. The straight line graph that could be drawn from the. Therefore Ohm’s law was verified

The constant of proportionality is called the "resistance", R. Resistors obey ohm’s law , thus the graph of V v/s I is a straight line and the equivalent resistance in series for n resistors is $R_{eq} = R_1 + R_2 + ... + R_n$ and in parallel is $1/R_{eq} = 1/R_1 + 1/R_2 + ... + 1/R_n$

Also, diode doesn’t obey ohm’s law thus the V-I graph for a diode is non-linear curve

Ohm's law is thus verified experimentally