lab 2

OHm's law

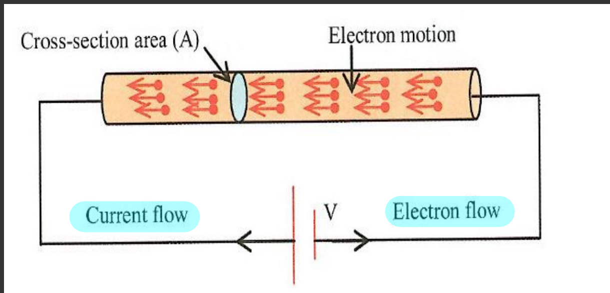
Resistance in series >>>> Normal addition

Resistance in parallel >>>> 1/r1 + 1/r2 ….
And then take the invert (1/x)

Ohm's law >>>> V = i R

Power = R I^2

This flow of charge is called electric current (I), which is defined as the charges that pass a given cross section of the conductor per unit time. If the rate of flow of charge is constant with time, then



When a conductor is connected to a battery as in Fig.1, the potential difference between the ends of the conductor creates an electric field **E** inside the conductor. This field applies an electric force $\mathbf{F}_E$ on the charge q (the free electrons) of the conductor and accelerates them toward the positive terminal of the battery according to the equation

The flow of charge in Fig.1 encounters an opposition force due the interaction (such as collisions) of free electrons with other electrons and atoms or ions in the conductor. This opposition force is called electric resistance R and the conductor is called a resistor.

The electric force does work to move the electrons between the two ends of the resistor. This work is converted into thermal energy (heat) in the resistor. The power of a device is defined as the rate at which it converts energy from one form into another (electric energy to thermal energy in this case), or equivalently the rate at which work is done.

$$P = \frac{dW}{dt} = \frac{d}{dt}(\mathbf{F}_E.\mathbf{L}) = \frac{d}{dt}(q\,\mathbf{E}.\mathbf{L}) = I(\mathbf{E}.\mathbf{L}) \quad (3)$$

The quantity **E.L** is the potential difference across the resistor. Thus the power dissipated in the resistor is

$$P = IV = I^2R = V^2/R \quad \text{(Joule's law)} \quad (4)$$

1. Ohm's law

Ohm's law is one of the most important relationships in electric circuit analysis. It states that the resistance of the element does not change by changing the current or the voltage across the element.

$$V = RI \quad \text{(Ohm's law)} \quad (5)$$

Elements obeying Ohm's law are called ohmic and those that do not obey Ohm's law are called non-Ohmic. Eq. (5) is valid whether the element is ohmic or not. The difference is that if the element is ohmic, R is constant for any value of V and I whereas for non-ohmic materials, R has different values for different V and I as shown in Fig. 2. Since R depends on the geometrical shape of the resistor, Eq. (5) is called the macroscopic form of Ohm's law

Ohm's Law

V(v)	I(A)	R=V/I(Ω)	Power=RI²(w)
4	0.04	100	0.16
6	0.06	100	0.36
8	0.07	114.2	0.56
10	0.1	100	1
12	0.11	109	1.32
14	0.13	107.6	1.82
16	0.17	95	2.72

Part II: For R_1=100 Ω, R_2=200 Ω and R_3= 500 Ω, calculate the equivalent resistance theoretically and experimentally in the following cases:

1) The three resistances are in series

R_{eqth}=800 ohm

V= 20 v and I= 24 mA

R_{eqexp}=V/I= 833.33 ohm

Compare the results:

2) The three resistances are in parallel

R_{eqth}=58 ohm

V= 20 v and I= 0.338 A

R_{eqexp}=59.2 ohm

Compare the results:

Series

The resistors in series are characterized by two points

1) The current of each resistor equals the total current.
2) The total voltage is the sum of the voltages across each resistor

Applying these two points as well as Ohm's law, we get

$$R_{eq} = R_1 + R_2 + R_3 + \ldots = \sum_n R_n \quad (8)$$

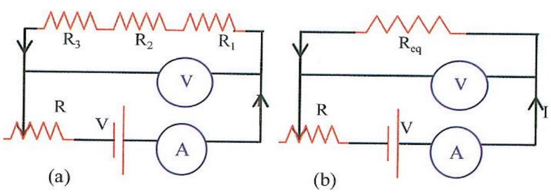


Fig. 3: Series resistors and (b) Their equivalent resistance

Parallel

Resistors in parallel are those connected to a common point at both ends in such a way that is a different path of current for different resistor as shown in Fig. 4. The resistors in parallel are characterize by

1) The voltage of each resistor equals the total voltage.
2) The total current is the sum of the current through each resistor.

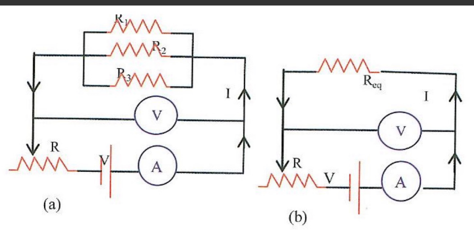


Fig. 4: (a) Parallel resistors and (b) Their equivalent resistance

1. Apparatus

Breadboard, power supply, DMM for voltage and resistance measurements, ammeter for current measurement, three resistors of different values, connection wires, potentiometer for current limited

lab 3

Meter bridge

cm

L1 = 100-L2

$$R_x = \frac{L_1}{L_2} R_s$$

Ω

Meter bridge is based on the principle of wheat stone bridge and it is used to find the resistance of an unknown conductor or to compare two unknown resistance. The practical diagram is shown in the below figure

THEORY:

Measuring theory of unknown resistance using the meterbridge depends on the balance between two branches in the bride, one branch where there is the known resistance and the other unknown one.

R is Known Resistance

S is Unknown Resistance

P is Resistance across AB

Q is the Resistance between BD

AC is a 1m long wire of uniform area of cross-section So that $L_1+L_2=100$

Assuming $L_1=L \Rightarrow L_2=100-L$

The unknown resistance 'X' of the given wire is obtained by relation :

$X = R\, L_2/L_1 = R\,(100-L)/L$

And specific resistance of the material of a given a wire is obtained by

$=2\pi r\, X/L$

where r = radius of the wire and L = length of wire.

#	$R_s(\Omega)$	L_2(cm)	L_1(cm)	$R_x(\Omega)$
1	30	27	73	81.11
2	50	39	61	78.205
3	70	47	53	78.936
4	90	53	47	79.811
5	110	58	42	79.655
6	130	62	38	79.677
7	150	65	35	80.679
8	170	68	32	80
9	190	71	29	77.606
10	210	73	27	77.671
11	230	75	25	76.66
12	250	76	24	78.947
				R_x= 79.1

Equations:

$L_1=100 - L_2$

$$R_x = \frac{L_1}{L_2} R_s$$

lab 4
Kirchhoff's law

Single loop | Multi loops

Single loop

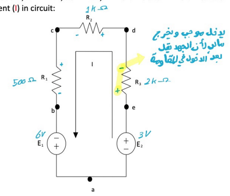
- Electric potential enters the resistance +ve and exits -ve
- The currents goes out of the +ve voltage

$$\sum V_i = 0$$

Kirchhoff's laws

1) Single Loop:

Let R1 = 500 Ω, R2 = 1 KΩ, R3 = 2 KΩ, E1 = 6 V DC and E2 = 3 V DC. Find the current (I) in circuit:



يدخل موجب ويخرج سالب لأن الجهد يقل بعد الدخول في المقاومة

$\sum V_i = 0$ * $3-(2\times10^3 I)-(1\times10^3 I)-(500 I)+6=0$ ("2000" for R_3, "1000" for R_2; V_2, R_3, R_2, R_1, V_1)

* $9-3500I=0$

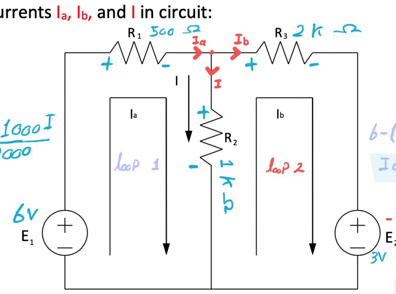
* $I=\frac{-9}{3500}=-2.57mA$ → فقط اغير اتجاه التيار

Multi loops

- Get each I separately then do I= I1 - I2
- You chose the current path
- Always start the loop by the battery

2) Multi-Loops:

A) Let R1 = 500 Ω, R2 = 1 KΩ, R3 = 2 KΩ, E1 = 6 V DC and E2 = 3 V DC.
Find the currents I_a, I_b, and I in circuit:



loop 1
loop 2

$I = I_a - I_b$

$I = \frac{24-4000I}{2000} + \frac{3-1000I}{2000}$

$I = \frac{27-5000I}{2000}$

$I = 3.86\ mA$

$\sum V_i = 0$

$6-(500I_a)-(1000I)=0$ (3.86mA)

$I_a = \frac{6-1000I}{500} = 4.28mA$

$-3+(1000I)-(2000I_b)=0$ (3.86mA)

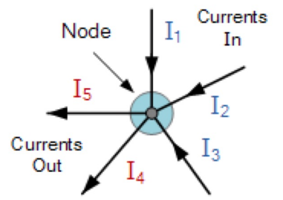
$I_b = \frac{3-1000I}{2000}$

$I_b = 4.28mA$

1. Kirchhoff's First Law – The Current Law, (KCL)

Kirchhoff's Current Law or KCL, states that the "*total current or charge entering a junction or node is exactly equal to the charge leaving the node as it has no other place to go except to leave, as no charge is lost within the node*". In other words the algebraic sum of all the currents entering and leaving a node must be equal to zero, $I_{(exiting)} + I_{(entering)} = 0$. This idea by Kirchhoff is commonly known as the Conservation of Charge.

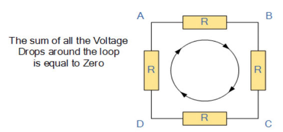
Currents Entering the Node Equals Currents Leaving the Node



$I_1 + I_2 + I_3 + (-I_4 + -I_5) = 0$

2. Kirchhoff's Second Law – The Voltage Law, (KVL)

Kirchhoff's Voltage Law or KVL, states that "*in any closed loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop*" which is also equal to zero. In other words the algebraic sum of all voltages within the loop must be equal to zero (Fig. 2).



$V_{AB} + V_{BC} + V_{CD} + V_{DA} = 0$

Here, the 3 currents entering the node, I_1, I_2, I_3 (Fig.1) are all positive in value and the 2 currents leaving the node, I_4 and I_5 are negative in value.

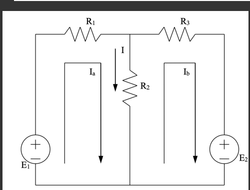
$I_1 + I_2 + I_3 - I_4 - I_5 = 0$

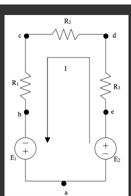
The term **Node** in an electrical circuit generally refers to a connection or junction of two or more current carrying paths or elements such as cables and components.

the Kirchhoff's law ($I_{th} = \frac{E_1 - E_2}{R_1+R_2+R_3}$).

3. Multi-loops

The circuit in **Fig. 4** was constructed and each resistor was measured with a multimeter to determine its actual value. Also, the voltages across the voltage sources E_1 and E_2 were measured to determine their actual values. Then the current loops I_a and I_b were measured along with the branch current I. Using the Mesh Current Method and the measured values of E_1, E_2, R_1, R_2, and R_3, the values of I_a, I_b, and I were calculated and compared with the measured values.





- **Circuit** – a circuit is a closed loop conducting path in which an electrical current flows.
- **Node** – a node is a junction, connection or terminal within a circuit were two or more circuit elements are connected or joined together giving a connection point between two or more branches. A node is indicated by a dot.
- **Branch** – a branch is a single or group of components such as resistors or a source which are connected between two nodes.
- **Loop** – a loop is a simple closed path in a circuit in which no circuit element or node is encountered more than once.

lab 5

Electric field and Potenital

-Electric field magnitude = V ”Electric potential” / x “Distance”

V / x   -SI unit >> v/m

-Electric field lines goes out of the +ve charge and goes into the -ve charge

-Equipotential surfaces lines always perpendicular on the electric field lines

The equipotential surface is defined as a surface (or line) that all points in this surface have the same potential.

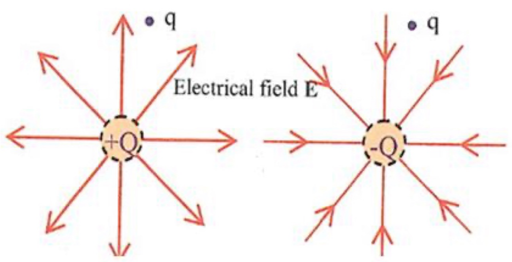


Fig. 1: Electrical fields for positive charge and negative

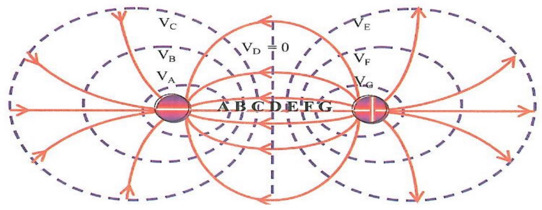


Fig. 2: Electric field and equipotential for two equal but opposite point charges

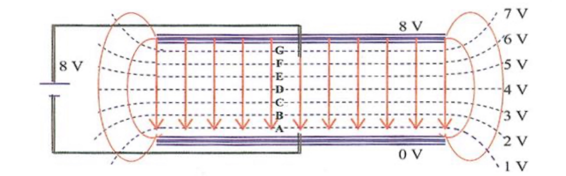


Fig. 3: Electric field and equipotential lines for a two parallel plate capacitor

APPARATUS:

- DC power supply
- mapping board
- Digital voltmeter
- carbonized paper sheets with printed metal electrodes
- connecting wires

V_s= 8v

Point	Position X (cm)	Potential V(v)	Electric Field Magnitude (v/m)
A	0.01 1	V_A= 1	100 N/C
B	0.02 2	V_B= 2	E_{AB}= 100 N/C
C	0.03 3	V_C= 3	E_{BC}= 100 N/C
D	0.04 4	V_D= 4	E_{CD}= 100 N/C
E	0.05 5	V_E= 5	E_{DE}= 100 N/C
F	0.06 6	V_F= 6	E_{EF}= 100 N/C
G	0.07 7	V_G= 7	E_{FG}= 100 N/C
S	0.08 8	V_S= 8	E_{GS}= 100 N/C

1) Complete the table by using $E=\Delta V/\Delta X$.

lab 6

RC Circuits

Capacitors are one of the most common elements in electrical circuits. Hardly find an electric circuit without containing capacitors.

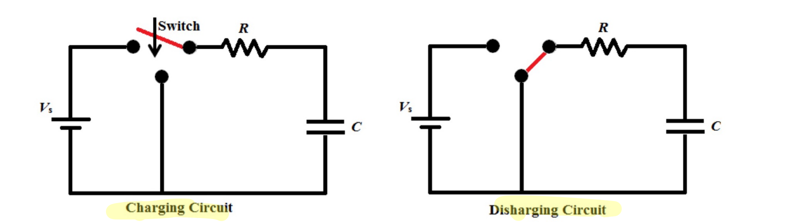
In this experiment, we will discuss the characteristics of the electric capacitor and study the charging process of the RC circuit.

The charge (Q) on the plates of the capacitor is determined by the voltage (V) across the capacitor terminals and its capacitance (C) through the relation.

$$Q = CV$$

The charging (**storage**) and discharging (**release**) process of capacitor is never instant but take a certain amount of time to occur.

The time constant (τ) is a characteristic quantity of the RC circuit. For practical purpose the capacitor can be assumed to be fully charged or fully discharged after time equal to 5τ.



When we start, the capacitor will gradually charge up through the resistor until the voltage across it reaches the supply voltage of the battery.

As the capacitor charges up, the potential difference across its plates slowly increases according to the relation

$$V_C = V_S(1 - e^{-t/\tau})$$

The actual **time taken to reach 63% of its maximum possible voltage** is known as the time constant (τ).

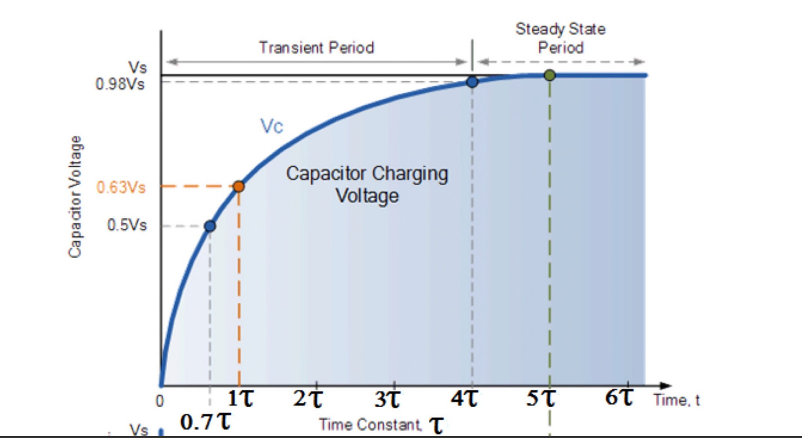
Then, if we move the switch the capacitor will gradually discharge through the resistor. The potential difference across its plates slowly decreases according to the relation.

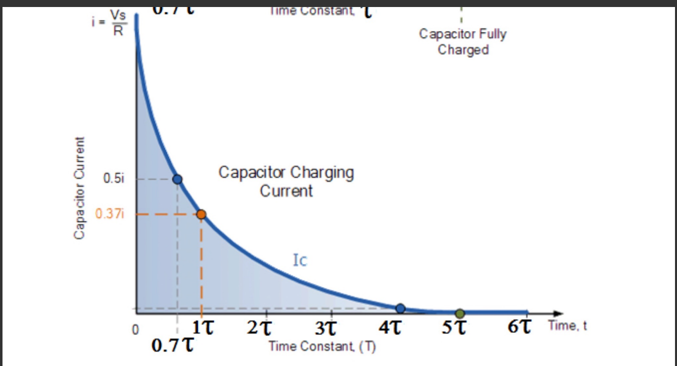
$$V_C = V_o e^{-t/\tau}$$

The actual **time taken to reach 37 % of its initial possible voltage** is known as the time constant (τ).

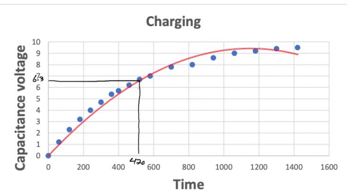
Mathematically, the time constant can be determined by

$$\tau = RC$$

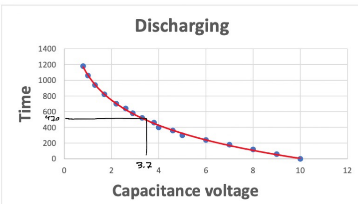




t	v
0	0
60	1.2
120	2.3
180	3.2
240	4
300	4.7
360	5.4
400	5.7
460	6.2
520	6.7
580	7
700	7.8
820	8
940	8.6
1060	9
1180	9.2
1300	9.4
1420	9.5



t	V
0	10
60	9
120	8
180	7
240	6
300	5
360	4.6
400	4
460	3.8
520	3.3
580	2.9
640	2.6
700	2.2
820	1.7
940	1.3
1060	1
1180	0.8



lab 7

Inductance of a Coil

Inductance is the name given to the property of a component that opposes the change of current flowing through it and even a straight piece of wire will have some inductance.

In an electrical circuit, when the electromotive force is induced in the same circuit in which the **current is changing** this effect is called **Self-induction** (L). Now in an AC circuit, the **opposition to current** flow through the coils windings not only depends upon the **inductance** of the coil but also the **frequency** of the AC waveform.

In the purely inductive circuit above, the inductor is connected directly across the AC supply voltage. As the supply voltage increases and decreases with the frequency, the self-induced back emf also increases and decreases in the coil with respect to this change.

We know that this self-induced emf is directly proportional to the rate of change of the current through the coil. The ratio of voltage to current in an inductive circuit will produce an equation that defines the **Inductive Reactance** (X_L) of the coil.

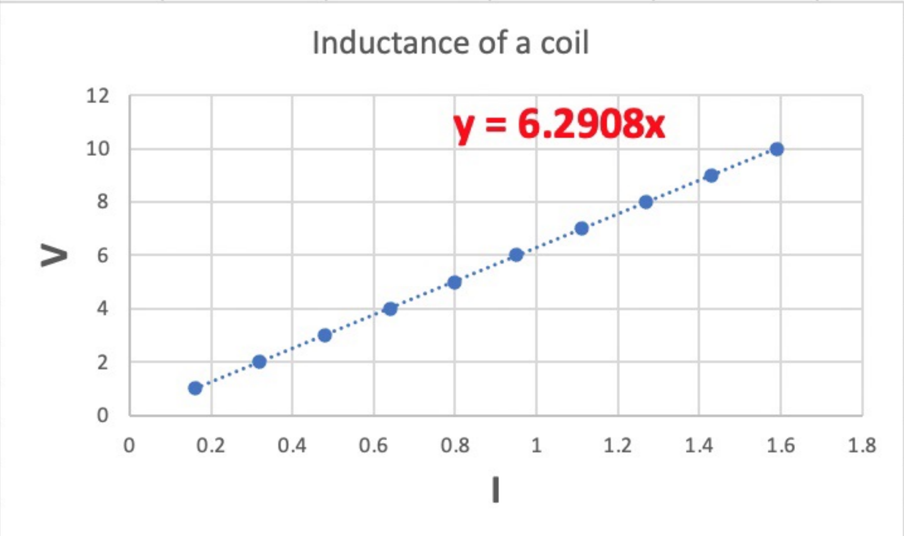
$$X_L = \frac{V_L}{I_L} = 2\pi f L$$

V_L (volt)	I_L (A)	$X_L = V_L/I_L$ (Ω)

The frequency (*f*) = 50 Hz

$$L = \frac{X_L}{2\pi f} = \frac{X_L}{2\pi f} = \;---\; H$$

v	I	X1"ohm"	L"H"
1	0.16	6.25	0.02
2	0.32	6.25	0.02
3	0.48	6.25	0.02
4	0.64	6.25	0.02
5	0.8	6.25	0.02
6	0.95	6.32	0.02
7	1.11	6.31	0.02
8	1.27	6.31	0.02
9	1.43	6.3	0.02
10	1.59	6.29	0.02



lab 8

Tangent Galvanometer

When a bar magnet is suspended in two Magnetic fields B and Bh, it comes to rest making an angle θ with the direction of Bh.

Tangent galvanometer is an early measuring instrument for small electric currents. It consists of a coil of insulated copper wire wound on a circular non-magnetic frame. Its working is based on the principle of the tangent law of magnetism. When a current is passed through the circular coil, a magnetic field (B) is produced at the center of the coil in a direction perpendicular to the plane of the coil. The TG is arranged in such a way that the horizontal component of earth's magnetic field (Bh) is in the direction of the plane of the coil. The magnetic needle is then under the action of two mutually perpendicular fields. If θ is the deflection of the needle, then according to tangent law,

$$B = B_h \tan\theta \text{..........(1)}$$

Tangent Galvanometer

Current (A)	Deflection angle (θ)	B_{coil} (T)	Tan(θ)	B_H (T)	K (A)
3.5E-3	20	1.04E-5	0.36	2.86E-5	9.60E-3
5.5E-3	30	1.64E-5	0.58	2.84E-5	9.53E-3
8.2E-3	40	2.44E-5	0.84	2.91E-5	9.77E-3
12.1E-3	50	3.6E-5	1.19	3.02E-5	0.01
17.5E-3	60	5.21E-5	1.73	3.01E-5	0.01
The radius of the coil R= 6.75E-2 m					
Number of turns N = 320 turns					
$\mu_0 = 4\pi E\text{-}7$ T.m/A					

Equations:

$$B_{Coil} = \frac{\mu_0 N I}{2R}, \quad K = \frac{2RB_H}{\mu_0 N} = I/\tan\theta, \quad B_H = \frac{B_{Coil}}{\tan\theta}$$