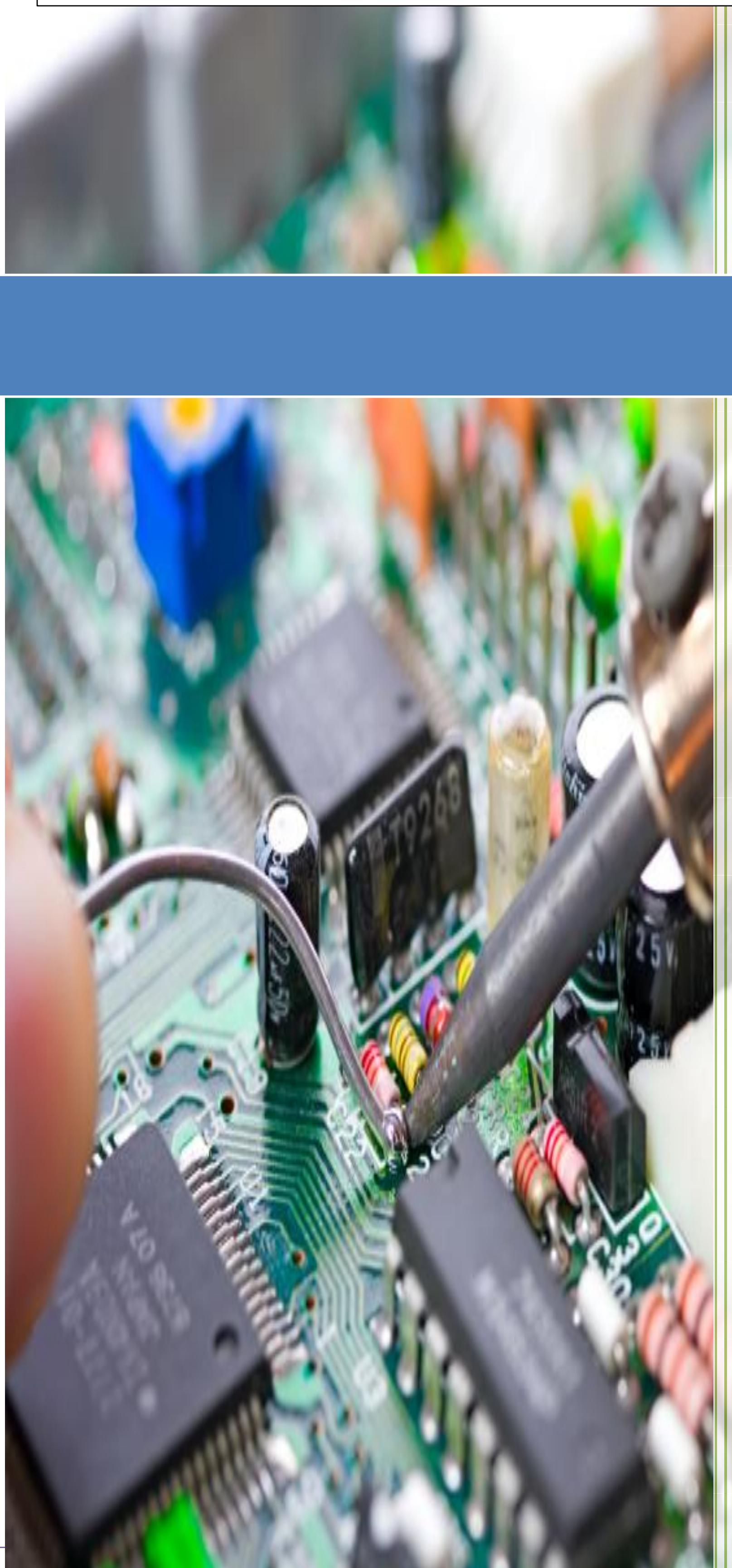
DEPARTMENT OF COMPUTER ENGINEERING
UNIVERSITY OF LAHORE



NAME

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Section

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UNIVERSITY OF LAHORE

Department of Computer engineering

Linear Circuit Analysis Laboratory Manual 2

Compiled by Engr. Ahmad Bilal

Name		**Roll Number**	
Section		**Semester**	

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LAB EXPERIMENT	**DATE**	**GRADE**	**SIGNATURE**
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Experiment 8
Kirchhoff’s Voltage and Current Law:

OBJECTIVE:

1.To verify experimentally Kirchhoff’s Voltage Law

2. To verify experimentally Kirchhoff’s Current Law

Material Required:

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1. Resistors,
2. DMM
3. DC power supply.

THEORY:

1)KIRCHOFF‟S VOLTAGE LAW:

Explanation:

Consider the simple series circuit Fig. . Here we have numbered the points in the circuit for voltage reference.

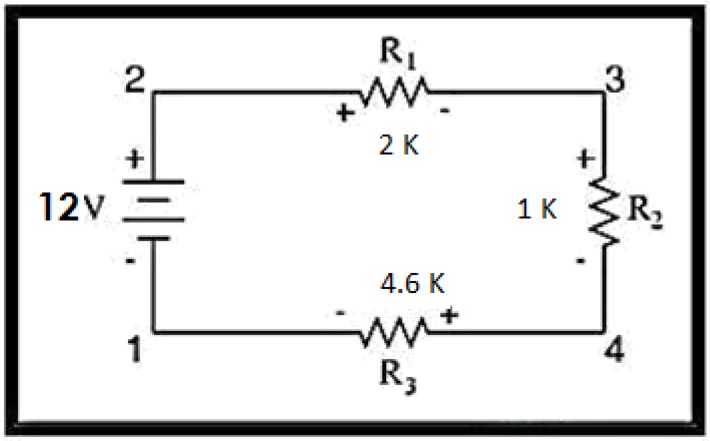
As we are dealing with dc circuits, therefore we should carefully connect the voltmeter while measuring voltage across supply or any of the resistances as shown in fig.5.2, keeping in mind the similarity of polarities of voltage across the element and that of the connected probes of meter. In such case, we will observe that,

$$
\begin{array}{rrl}
E_{2\text{-}1} = & +45\ \mathrm{V} & \textit{voltage from point } \mathbf{2} \textit{ to point } \mathbf{1} \\
E_{3\text{-}2} = & -10\ \mathrm{V} & \textit{voltage from point } \mathbf{3} \textit{ to point } \mathbf{2} \\
E_{4\text{-}3} = & -20\ \mathrm{V} & \textit{voltage from point } \mathbf{4} \textit{ to point } \mathbf{3} \\
+\ E_{1\text{-}4} = & -15\ \mathrm{V} & \textit{voltage from point } \mathbf{1} \textit{ to point } \mathbf{4} \\
\hline
 & 0\ \mathrm{V} &
\end{array}
$$

This principle is known as ***Kirchhoff's Voltage Law***, and it can be stated as such:

"The algebraic sum of all voltages in a loop must equal zero"

TASK 1 : Experiment to verify that The algebraic sum of all voltages in a loop must equal zero



a)For KVL:

1. Construct circuit of fig. using the values R1 , R2, R3 as shown in the figure
2. Adjust the output of the power supply so that Vs = 12V. Measure and record this voltage in table. also measure and record the voltages V1, V2, V3 and enter the sum in the same table.

Table

V_T	V_1	V_2	V_3	Sum ($V_1+V_2+V_3$)

KIRCHHOFF‟S CURRENT LAW:

TASK 2 : Experiment to verify that The algebraic sum of all currents entering and exiting a node must equal zero

THEORY:

Then, according to Kirchhoff's Current Law:

"The algebraic sum of all currents entering and exiting a node must equal zero"

Mathematically, we can express this general relationship as such:

$$I_{entering} + (-I_{exiting}) = 0$$

That is, if we assign a mathematical sign (polarity) to each current, denoting whether they enter (+) or exit (-) a node, we can add them together to arrive at a total of zero, guaranteed.

Note:

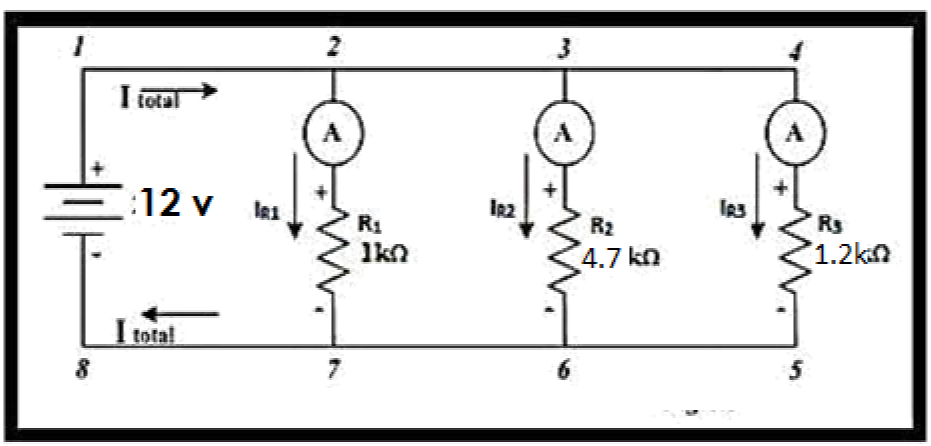
Whether negative or positive denotes current entering or exiting is entirely arbitrary, so long as they are opposite signs for opposite directions and we stay consistent in our notation, KCL will work.

PROCEDURE:

b)For KCL:

1- Connect the circuit of Fig.5 with Vs =12 V.

2- Measure and record in Table 5 currents I_{R1}, I_{R2}, I_{R3} and I_{total}.



OBSERVATIONS:

I_{total}	I_{R1}	I_{R2}	I_{R3}	Sum $(I_{R1}+I_{R2}+I_{R3})$

Experiment 9
SUPERPOSITION PRINCIPLE IN DC CIRCUITS.

OBJECTIVE:

1. To verify superposition principle in DC Circuits.

Material REQUIRED:

1. DMM,
2. 2 DC Power Supplies,
3. Resistances (1k Ω, 1.8k Ω, 470Ω).

THEORY:

The superposition principle states that :

“The current through or voltage across, any resistive branch of a multisource network

is the algebraic sum of the contribution due to each source acting independently.”

When the effects of one source are considered, the others are replaced by their internal resistances. This principle permits one to analyze circuits without restoring to simultaneous equations.

Superposition is effective only for linear circuit relationship. Non-linear effects, such as power, which varies as the square of the current or voltage, cannot be analyzed using this principle.

TASK 1 : Experiment to verify superposition Principal

1 - Construct the Network of where R1 = 1 k Ω , R2 = 470 Ω , R3 = 1.8 k Ω.Verify the resistances using DMM.

2 - Using superposition and measured resistance values, calculate the currents indicated in observation table (a), for the network of fig

Next to each magnitude include a small arrow to indicate the current direction for each source and for the complete network.

3 - Energize the network of fig and measure the voltages indicated in observation table

B, calculate current in table (b) using Ohm‟s Law. Indicate the polarity of the voltages and direction of currents on below figure

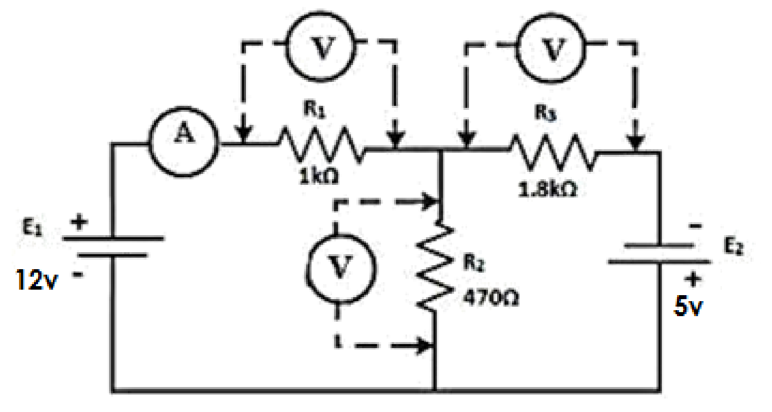


Figure A

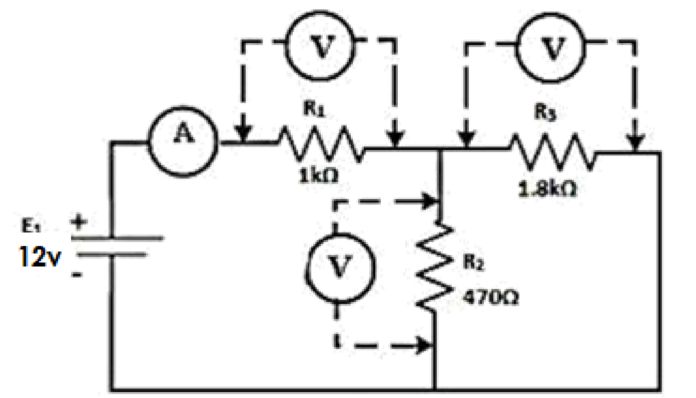


Figure B

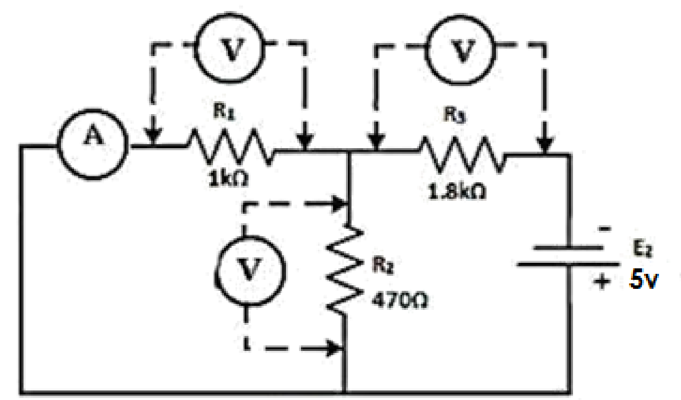


Figure C

4 - Construct the network of fig. b. Note that source E_2 has been removed.

5 - Energize the network of fig7. 2 and measure the voltages indicated in table C. Calculate currents using Ohm‟s Law.

6 - Repeat steps # 4 & 5 for the network of fig.c. Note that E_1 has been removed.

7 - Using the results of steps # 3, 5 and 6, determine the power delivered to each resistor and insert in table (e).

OBSERVATIONS:

Resistors:

	Nominal Values (Ω)	Measured Values (Ω)
1	1 KΩ	
2	470Ω	
3	1.8 KΩ	

a) Calculated Values for the Network of Fig:1

Due to E_1		Due to E_2		Algebraic Sum	
I_1‟ =	V_1‟=	I_1” =	V_1” =	$I_1 = I_1$‟+ I_1”=	$V_1 = V_1$‟+ V_1”=
I_2 ‟=	V_2‟=	I_2 ” =	V_2” =	$I_2 = I_2$‟+ I_2”=	$V_1 = V_1$‟+ V_1”=
I_3 ‟=	V_3‟=	I_3 ” =	V_3” =	$I_3 = I_3$‟+ I_3”=	$V_1 = V_1$‟+ V_1”=

b) Measured Values for the Network of Fig: 1

V_1 = ______________________________

V_2 = ______________________________

V_3 = ______________________________

I_1 = ______________________________

I_2 = ______________________________

I_3 = ______________________________

c) Measured Values for the Network of Fig:2

V_1 = ______________________________

V_2 = ______________________________

V_3 = ______________________________

I_1 = ______________________________

I_2 = ____

I_3 = ____

d) Measured Values for the Network of Fig. 3

V_1 = ____

V_2 = ____

V_3 = ____

I_1 = ____

I_2 = ____

I_3 = ____

e) Power Absorbed (use measured values of I and V)

Due to E_1	**Due to E_2**	**Sum of Columns 1 & 2**	**E1 & E2 Acting Simultaneously**	**Difference of Columns 3 & 4**

Experiment 10
Thevenin's Theorem

OBJECTIVE:

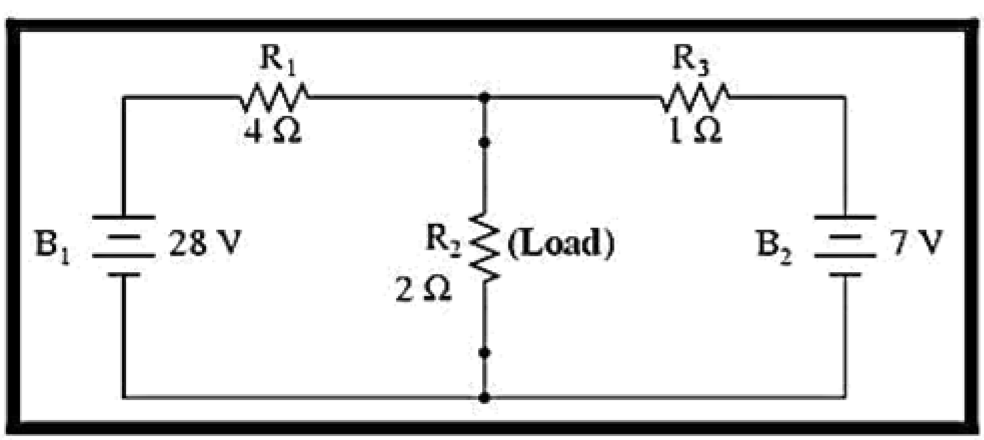
To determine by analysis the values VTH (Thevenin voltage) and RTH (Thevenin resistance) in a dc circuit containing a single voltage source

Material REQUIRED:

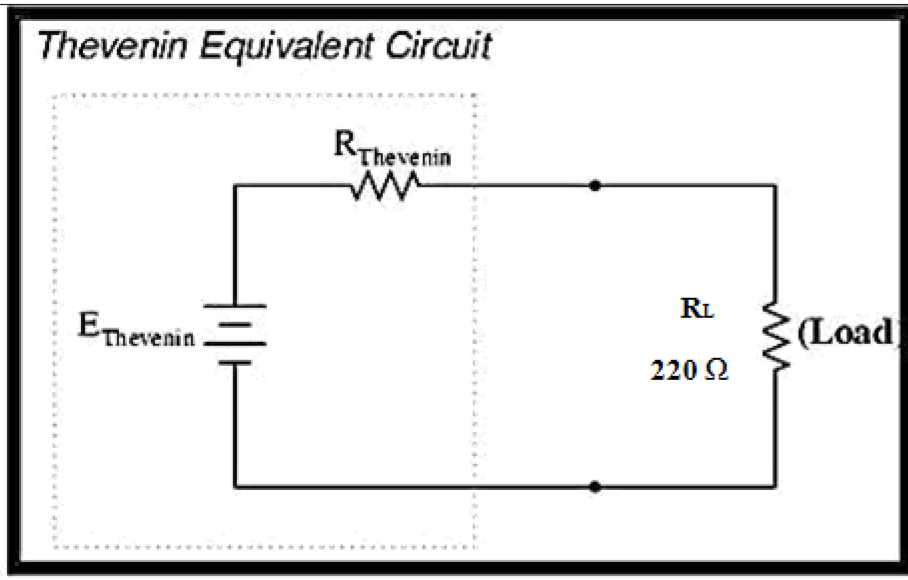
1. DMM,
2. 2 DC Power Supplies,
3. Resistances 47 ,220 ,330 , 1K

THEORY:

Thevenin's Theorem states that it is possible to simplify any linear circuit, no matter how complex, to an equivalent circuit with just a single voltage source and series resistance connected to a load. Thevenin's Theorem is especially useful in analyzing power systems and other circuits where one particular resistor in the circuit (called the "load" resistor) is subject to change, and re-calculation of the circuit is necessary with each trial value of load resistance, to determine voltage across it and current through it. Thevenin's Theorem makes this easy by temporarily removing the load resistance from the original circuit and reducing what's left to an equivalent circuit composed of a single voltage source and series resistance. The load resistance can then be re-connected to this "Thevenin equivalent circuit" and calculations carried out as if the whole network were nothing but a simple series circuit.



.Before Thevenin



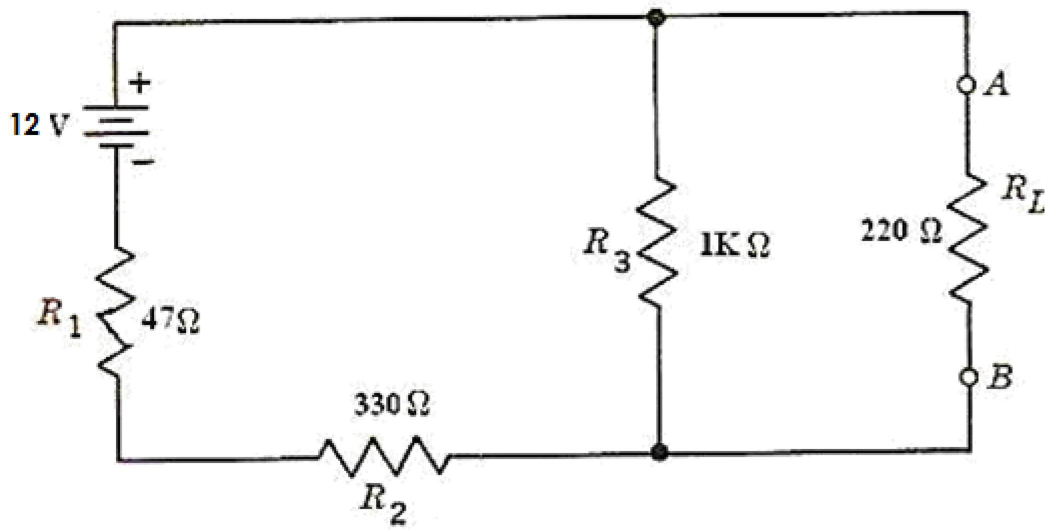
After Thevenin conversion

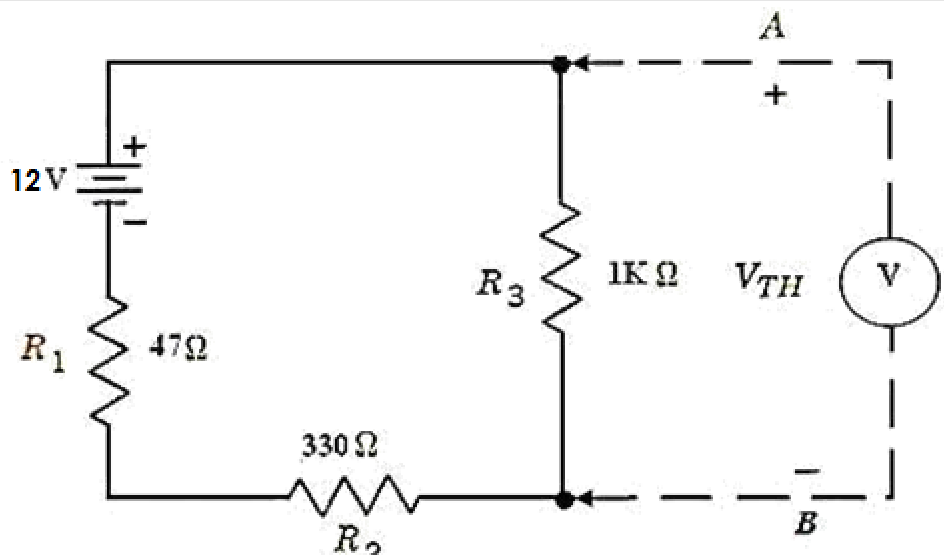
The "Thevenin Equivalent Circuit" is the electrical equivalent of B_1, R_1, R_3, and B_2 as seen from the two points where our load resistor (R_2) connects.

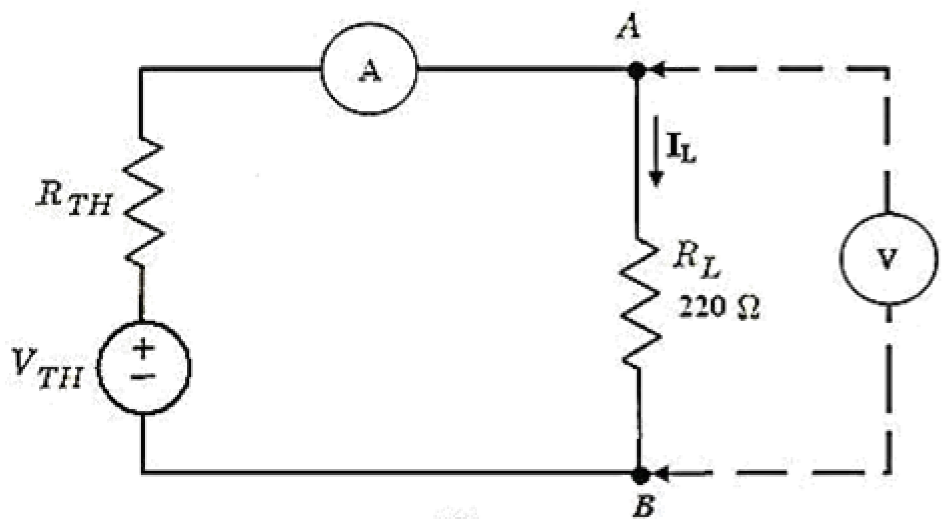
The Thevenin equivalent circuit, if correctly derived, will behave exactly the same as the original circuit formed by B_1, R_1, R_3, and B_2. In other words, the load resistor (R_2) voltage and current should be exactly the same for the same value of load resistance in the two circuits. The load resistor R_2 cannot "tell the difference" between the original network of B_1, R_1, R_3, and B_2, and the Thevenin equivalent circuit of $E_{Thevenin}$, and $R_{Thevenin}$, provided that the values for $E_{Thevenin}$ and $R_{Thevenin}$ have been calculated correctly.

PROCEDURE:

1. Connect the circuit as
2. Remove the R_L from the circuit across which the Thevinin equivalents have to be evaluated.
3. To find the R_{TH} remove the voltage-source from the circuit and short circuit the terminals from which the supply was connected. Now place an ohmmeter across the terminals A and B.
4. Also confirm the value of the equivalent resistance from calculations and record it in the table.
5. To find the value of V_{TH} place a voltmeter across the terminals A and B after retaining the voltage source in the circuit back.
6. Also confirm the value of the equivalent voltage from calculations and record it in the table.
7. Now construct the thevenin equivalent circuit and measure V_{AB} and $I_{L.}$ Also calculate the se values by using methods other than thevenin theorem


12 V
+
−
R_1
47Ω
330 Ω
R_2
R_3
1K Ω
A
R_L
220 Ω
B


12 V
+
−
R_1
47Ω
330 Ω
R_2
R_3
1K Ω
A
+
V_{TH}
V
−
B


A
R_{TH}
V_{TH}
A
I_L
R_L
220 Ω
V
B

OBSERVATIONS:

TABLE (a): Resistors

S:No:	Nominal Value(Ω)	Measured Value(Ω)
1	R_1=47	
2	R_2=330	
3	R_3=1000	
4	R_L=220	

TABLE (b): Thevenin's Theorem

R_L	V_{TH} (volts)		R_{TH} (ohms)		I_L (A)		V_{AB} (V)	
	Measured	Computed	Measured	Computed	Measured	Computed	Measured	Computed

Experiment 11
Norton Theorem and Theorem of Source Transformation

OBJECTIVE:

To verify Norton s Theorem and the theory of source transformation.

Material REQUIRED:

1. DC power supply
2. Ohmmeter
3. DC ammeter
4. DC voltmeter
5. Resistances of values 47 ,220 330 , 1K

THEORY:

Norton's theorem states that any two terminal network may be replaced by a simple equivalent circuit consisting of a constant current source IN, shunted by an internal resistance RN, Figure 9-1a shows the original network as a block terminated by a load resistance RL. Figure 9-lb shows the Norton equivalent circuit. The Norton current IN is distributed between the shunt resistance RN and the load RL. The current IL in RL may be found from the equation

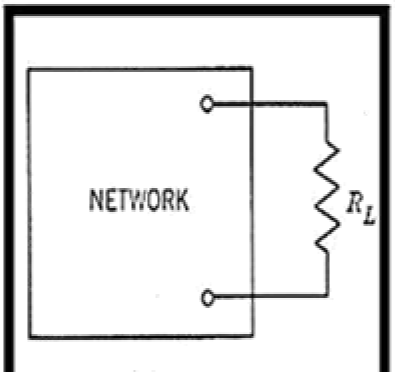
$$I_L = \frac{I_N \times R_N}{R_N + R_L}$$

The rules for determining the constants in the Norton equivalent circuit are as follows:

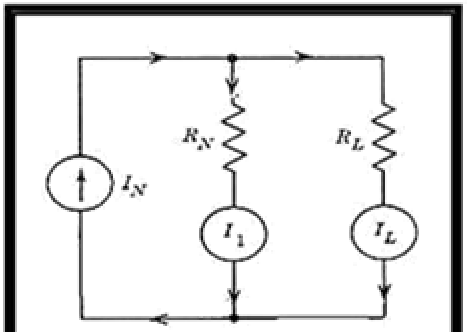
1. The constant current I_N is the current that would flow in the short circuit between the load resistance terminals if the load resistance were replaced by a short circuit.
2. The Norton resistance R_N is the resistance seen from the terminals of the *open* load, looking into the original network, when the voltage sources in the circuit are replaced by their internal resistance. Thus R_N is defined in exactly the same manner as is R_{TH} in Thevenin's theorem.

The ***theory of source conversion*** says that the Norton and Thevenine circuits can be terminally equivalent and related as follows:

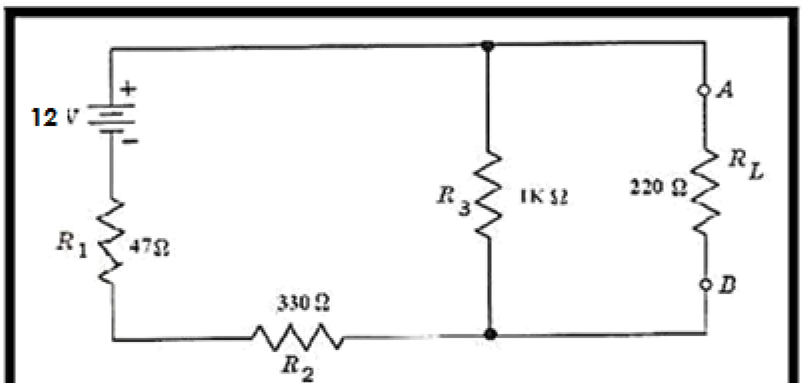
$\boxed{R_N=R_T}$ $\boxed{E_{TH}=I_N R_N}$ $\boxed{I_N = E_{TH}/R_{TH}}$



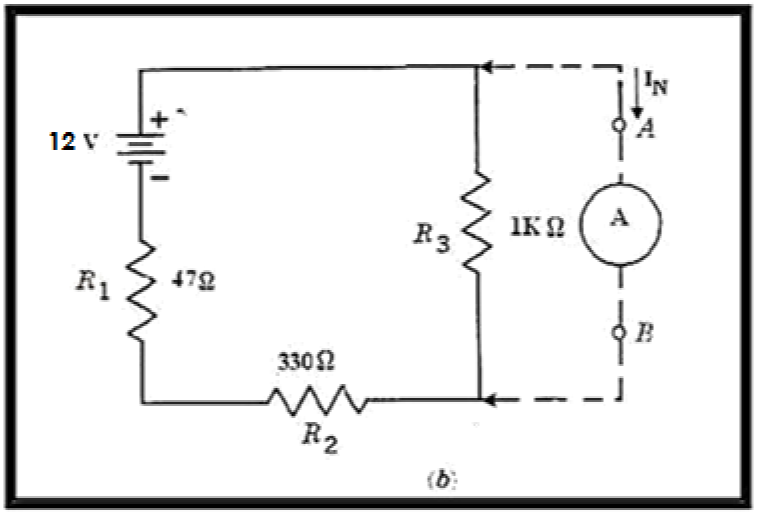
(a)

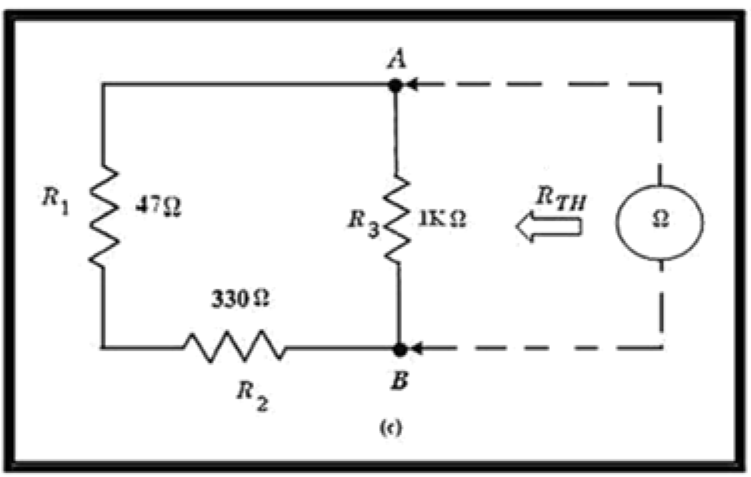


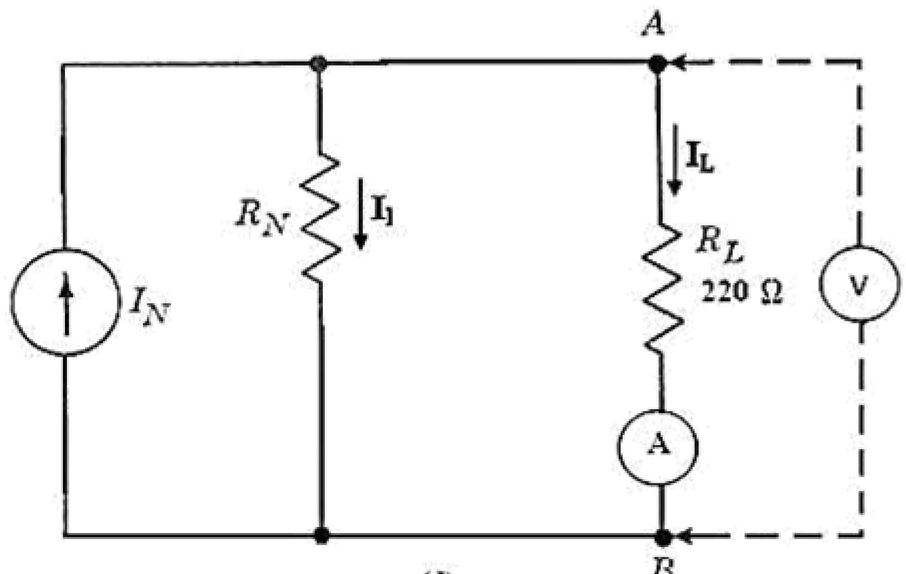
(b)



(a)


12 V
+
−
R1
47Ω
R3
1K Ω
A
I_N
A
B
330Ω
R2
(b)


A
R1
47Ω
R3
1K Ω
R_TH
Ω
330Ω
B
R2
(c)



(d)

PROCEDURE:

(a) NORTON‟S THEOREM:

1. Connect the circuit as shown in figure 2
2. Remove the R_L from the circuit across which Norton equivalents have to be found out.
3. For R_N or R_{TH} of the circuit, remove the voltage source and short circuit the open terminals. Now place an ohm meter across A and B.
4. Verify your observation, by calculating the R_{TH}.
5. For I_N, retain the source back into the circuit and place an ammeter connecting the terminals A and B.
6. The value of the current is the short circuit current i.e. I_N.
7. Also compute the value of the Norton‟s equivalent current and record it in the table.

7. Now construct the Norton‟s equivalent circuit and measure the IL and VAB. (That is vary the supply voltage until DMM indicates the value IN)Also calculate the value of IL and VAB by using methods other than Norton‟s theorem.

(b) Source Transformation:

1. Construct the Norton‟s equivalent circuit (That is vary the supply voltage until DMM indicates the value I_N).
2. Measure the supply voltage. Construct the thevinine equivalent circuit (d) from previous exp.
3. Measure V_{AB} and I_L.

4. **Are these values the same as obtained in part (a)?**

OBSERVATIONS:

TABLE (a): Resistors

S:No:	Nominal Value(Ω)	Measured Value(Ω)
1	**R_1=**	
2	**R_2=**	
3	**R_3=**	
4	**R_L=**	

TABLE (b): Norton"s Theorem

R_L Ω	I_N (A)		R_N (Ω)		I_L (A)		V_{AB} (V)	
	Measured	Computed	Measured	Computed	Measured	Computed	Measured	Computed

Experiment # 12 (a)   Non-inverting amplifier

Objective:

To understand the behavior of opamp in the case of using non inverting pins.

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Theory:

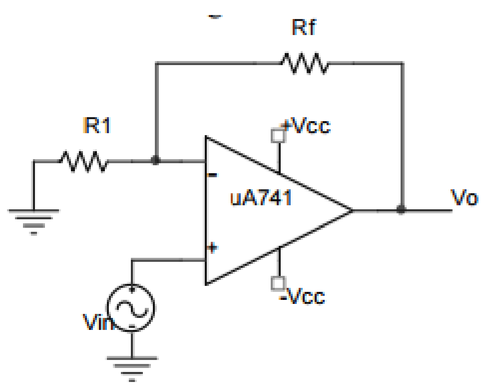
The input signal is applied to the non-inverting (+) input. The output is applied back to the inverting (-) input through the feedback circuit (closed loop) formed by the input resistor R1 and the feedback resistor Rf. This creates –ve feedback as follows. Resistors R1 and Rf form a voltage-divider circuit, which reduces VO and connects the reduced voltage Vf to the inverting input. The feedback is expressed as

$$V_f = \left(\frac{R_1}{R_1 + R_f}\right)Vo$$

The difference of the input voltage, Vin and the feedback voltage, Vf is the differential input of the opamp. This differential voltage is amplified by the gain of the op-amp and produces an output voltage expressed as

$$Vo = \left(1 + \frac{R_f}{R_1}\right)V_{in}$$

Circuit diagram:



Non-inverting amplifier configuration of op-amp

Calculations:

$V_{IN}(v)$	$V_{OUT}(v)$

(b)Application Of non-inverting amplifier

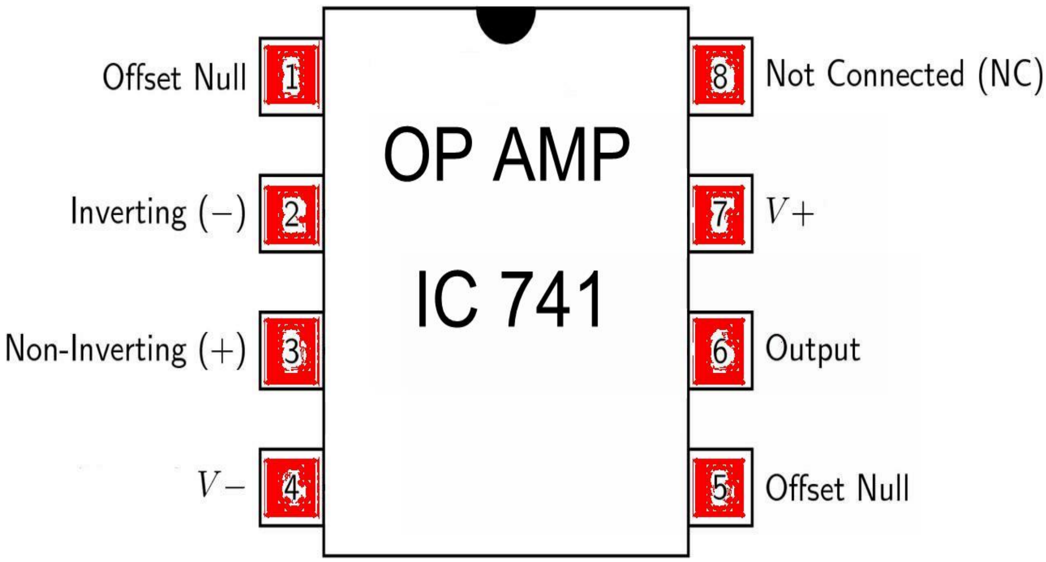
Objective: To understand the application of non-inverting amplifier.

Apparatus:

741 IC
10uf
Potentiometer
Red & green Led
Resistors 10kohm, 330kohm
Supply (9v)

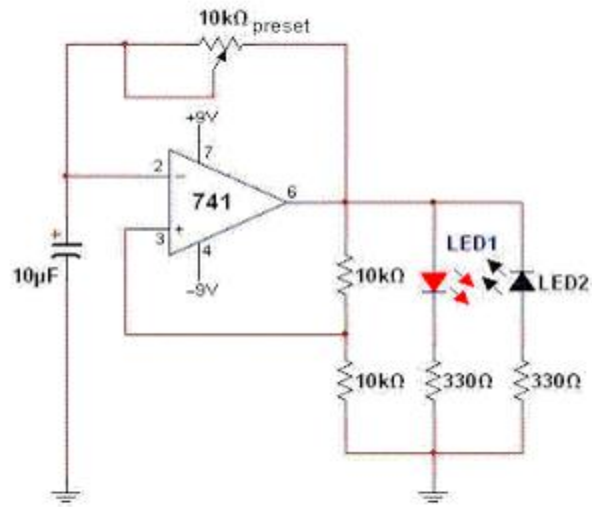
Theory:

It is the simple circuit of non-inverting opamp. We apply the 9v across the 741 IC. The data sheet of the IC is given bellow.



The pin 2 is connected with capacitor and then grounded it means that when the capacitor charge then red led is glow and when the capacitor is discharge then blue led is glow. We want to find out the charge and discharge voltage across the led.

Circuit diagram:



Calculations:

V_{in}	V_{Led1}	V_{led2}

Experiment 12(b)

Charging and Discharging of a Capacitor

Objective:

The objective of this experiment is to verify the exponential behavior of capacitors during charging and discharging processes.

Apparatus:

A capacitor, a resistance box, 2 multi-meters, connecting wires, a watch, a dc power source, and a 2-way switch

Theory:

A **capacitor** is a passive electric device that **stores electric energy.** A parallel-plates capacitor is made of two parallel metallic surfaces, each of area **A**, separated by an insulation layer of thickness **d**, and it has a **capacity of**

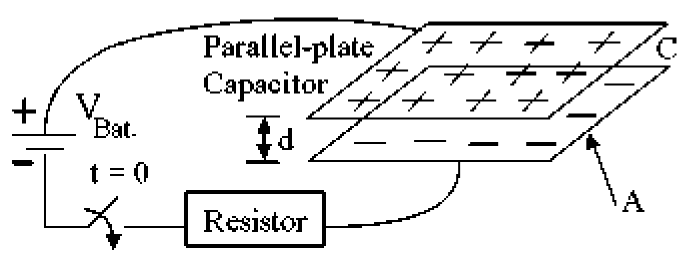
$$C = \varepsilon_0 \kappa \frac{A}{d}$$

where **C** is the **capacity in Farads**, **A** the **area** of each plate in **m**^{2}, **d** the **insulation (dielectric) thickness in (m)**, and **ε_o** the **permittivity of free space (vacuum)** for electric field propagation expressed in **F/m** that reads **Farads/meter.**

The factor, κ , pronounced "***kappa***" denotes the ***dielectric constant***, and depends on the material of the insulation layer**.** The ***capacitance C*** does not depend on the material of the plates**.** The dielectric constant ε_o is related to Coulomb's constant ***k*** by

$$\varepsilon_o = \frac{1}{4\pi k} = 8.85\text{x}10^{-12}\,\frac{F}{m}$$

The resistor in the circuit controls the charging pace.



In ***Fig***, at ***t = 0***, the capacitor is uncharged**.** As soon as the key in the circuit is closed, electrons flow from the negative pole of the battery toward the lower plate of the capacitor**.** They distribute over the lower plate, making it negative**.** At the same time, the repelled free electrons of the upper plate flow toward the positive pole of the battery**.** This causes the upper plate to become positively charged. This process does not happen suddenly. It takes some time. The current is greatest to begin with, and decreases as charges accumulate on the plates. At the beginning the capacitor is empty; therefore, the voltage across it is zero, but as more and more charges build up on its plates, its voltage keeps increasing. The voltage across the capacitor V_C asymptotically approaches the battery voltage V_{Bat}.

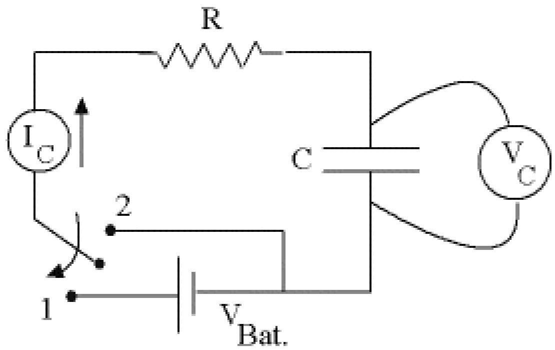
During the charging and discharging processes, the voltage across the capacitor and the current through it follow the following ***exponential*** equations:

(**Charging**) **Battery in Circuit**	$V_C = V_{Bat}(1 - e^{\frac{-t}{RC}})$ $I_C = \frac{V_{Bat}}{R} e^{\frac{-t}{RC}}$	**At t = 0,** $V_C = 0$ $I_C = V_B / R$	**As** $t \rightarrow \infty$ $V_C = V_{Bat.}$ $I_C = 0$
(**Discharging**) With battery removed, the initial capacitor voltage is $V_o = Q_o/C$ making the initial current $I_o = V_o/R$	$V_C = \frac{Q_o}{C} e^{\frac{-t}{RC}}$ $I_C = \frac{Q_o}{RC} e^{\frac{-t}{RC}}$	**At t = 0,** $V_C = Q_o/C$ $I_C = Q_o/(RC)$	**As** $t \rightarrow \infty$ $V_C = 0$ $I_C = 0$

It is a good idea to examine the values in the third and fourth columns by once setting **t = 0** and once $t \rightarrow \infty$ in the appropriate equations. Note that the ***charge-voltage formula*** for a capacitor is $Q = CV$. These ***exponential variations*** will be observed in this experiment.

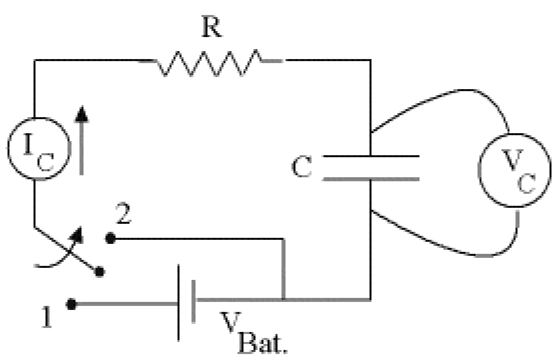
Procedure:

Arrange a circuit as shown**:**



If a computer is used to ***directly*** graph V_C and I_C versus ***time*** via an ***electronic interface***, there is no need for using large capacitance ***C*** and a large resistance ***R*** in order to have a large value for the time constant $\tau = RC$. If voltage, current, and time are measured by three different group members, then use of large capacitance and resistance is recommended in order to have a large value for τ so that relatively accurate measurements (readings) can be made**.** The ***two-way switch*** shown is first put in ***position 1*** to start the ***charging process.*** In this case, the group member who keeps track of time must also close the circuit at the same time he/she starts the stop watch**.** He/she must also announce the time at equal intervals**.** When he/she announces the time, two other group members read the current and voltage values**.** A good value for τ is ***20s***, and intervals of ***10s*** will give each experimenter enough time to read and record a value, and concentrate on the occurrence of the next value**.** Obtaining ***10 to 15 points*** for each of current and voltage is sufficient**.** The data may be exchanged between the experimenters afterwards**.** ***Do not disconnect the circuit.*** This is because while preparation is underway for the discharging part of the experiment, the capacitor voltage keeps increasing asymptotically toward the battery voltage**.**

When all members are ready for the second part of the experiment (the discharging of the capacitor), the timekeeper must be ready to announce the starting time and at the same time put the ***two-way switch*** *in* ***position 2*** as shown in ***Fig*** below**:**



Graphs:

Graph the following: For charging**:** V_C versus **t** and I_C versus **t**, and
for discharging**:** V_C versus **t** and I_C versus **t.**

of $I_C(t)$ for the charging process**:** If $\ln(I_C)$ is graphed versus **t** , a **straight line** will be obtained**.** To understand why, let us consider the equation

$I_C = I_o e^{\frac{-t}{RC}}$. Taking the *natural log* of both sides, we get :

$\ln(I_C) = \ln(I_o) - \frac{1}{RC}t$. Comparing this with the equation

of a straight line (y = b + mx), we may write:

$$y = \ln(I_C) \quad ; \quad b = \ln(I_o) \quad ; \quad m = -\frac{1}{RC} \quad ; \quad x = t .$$

Note that variables y and x are replaced by $\ln(I_C)$ and t and the

slope is $m = -\frac{1}{RC}$. When $\ln(I_C)$ is graphed, the slope must

be determined from it. Then $RC = -\frac{1}{m}$. This gives the experimental value for RC. The accepted value is the actual product of *R* and *C* used in the experimnet. A percent error may then be calculated.

Data:

Given:

V_B = the battery voltage (to be read at the start of charging)
V_{oC} = the initial capacitor voltage (to be read at the start of discharging)
Let **R = 20kΩ and C = 1,000 μF** such that **τ = 20s.**
Use other values if suggested by your instructor**.**

Measured:

Capacitor Charging:
Note: I_C at **t = 0** is Known. $I_C = V_B/R$ **.**

t (sec)	0	10	20	30	40	50	60	70	80	90	100	110	120	130
V_C (volts)	0													
I_C (Amps)	V_B/R													

Capacitor Discharging:

Note: $\boldsymbol{I_C}$ ***at t = 0 is Known.*** $\boldsymbol{I_C = V_{oC}/R}$**.**

t (sec)	0	10	20	30	40	50	60	70	80	90	100	110	120	130
V_C (volts)	V_{oC}													
I_C (Amps)	V_{oC}/R													

Calculations:

For the charging part**:** $I_o = V_B/R$**.**

For the discharging part $I_o = V_{oC}/R$**.**

Conclusion:

Project 1