INTRODUCTION TO ELECTRONICS LAB EC29003 EXPERIMENT 01

MEASUREMENT OF RESISTANCE AND CLASSIFICATION OF CAPACITANCE

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EXPERIMENT O1

MESUREMENT OF RESISTANCE AND CLASSIFICATION OF CAPACITANCE

<u>AIM:</u> To find the values of resistances from the color bands on the resistors along with their permitted tolerance values. To identify capacitance values from the codes marked on them. To perform the experiments under Virtual Labs.

<u>THEORY:</u>

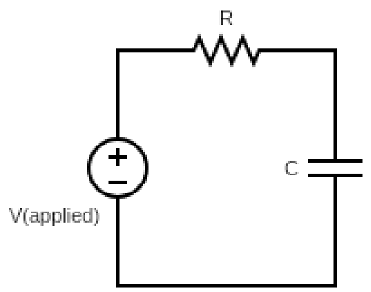
OHM'S LAW

Ohm's Law states that the current through a conductor between two points is directly proportional to the voltage across the two points. Introducing the constant of proportionality, the resistance, one arrives at the usual mathematical equation that describes this relationship as follows .

$$\boldsymbol{I = \frac{V}{R}}$$

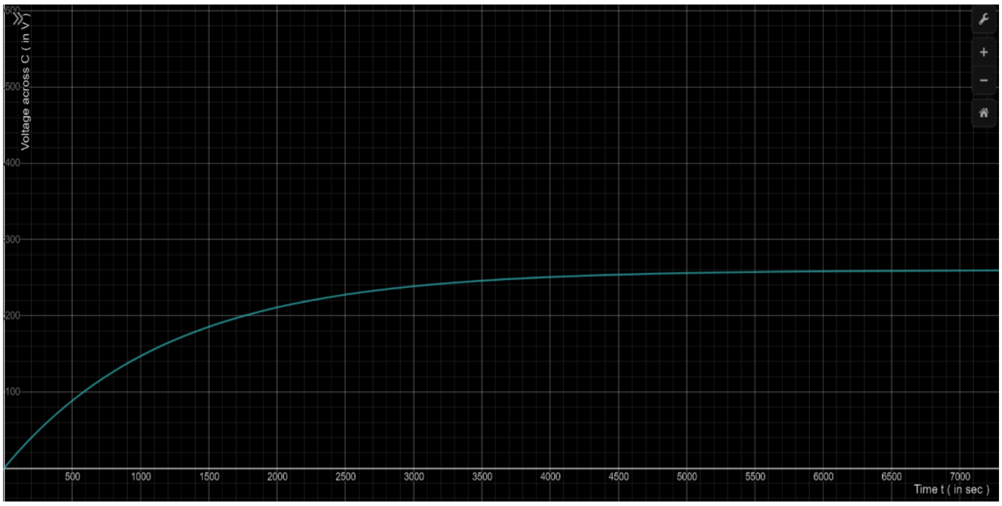
Resistance is measured in ohms (Ω) where one ohm is defined as the resistance that produces a potential difference of one volt when a current of one ampere passes through it .

CAPACITOR CHARGING



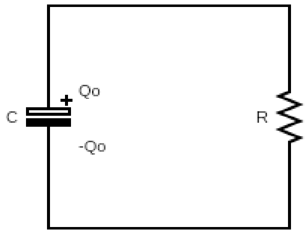
$$\boldsymbol{Q(t) = CV_{applied}(\,1 - \,e^{-t/RC}\,)}$$

The following is the potential difference across a 120mF capacitor (initially uncharged) as a function of time when it is connected in series with a resistor of 10kΩ resistance and a DC voltage source of 260 V .



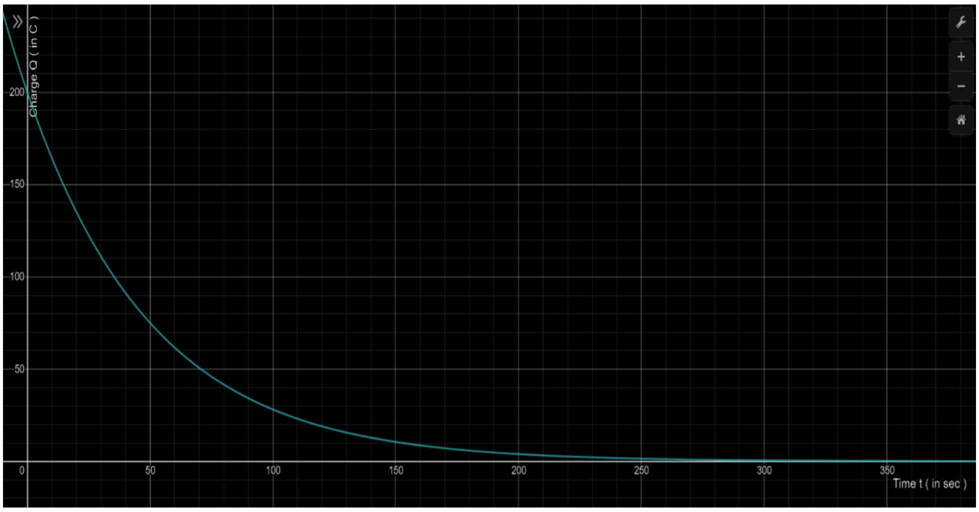
from Desmos

CAPACITOR DISCHARGING



$$\boldsymbol{Q(t) = Q_O\, e^{-t/RC}}$$

The following is the charge on a 5.10mF capacitor (initially charged to 200 C) as a function of time when it is connected in parallel to a resistor of 10kΩ resistance .



from Desmos

THEVENIN'S THEOREM

Any linear electrical network containing only voltage sources, current sources and resistances can be replaced at terminals A-B by an equivalent combination of a voltage source V_{th} in a series connection with a resistance R_{th}.

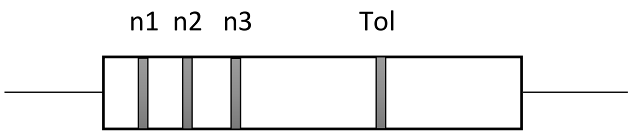
The equivalent voltage V_{th} is the voltage obtained at terminals A-B of the network with terminals A-B open circuited.

The equivalent resistance R_{th} is the resistance that the circuit between terminals A and B would have if all ideal voltage sources in the circuit were replaced by a short circuit and all ideal current sources were replaced by an open circuit.

If terminals A and B are connected to one another, the current flowing from A to B will be V_{th}/R_{th}. This means that R_{th} could alternatively be calculated as V_{th} divided by the short-circuit current between A and B when they are connected together.

PROCEDURE:

1) Identification of Resistance



R = n1 n2 x 10^{n3} +/- Tol Ω

The color bands on resistors were used to find the nominal values of their resistance and the permitted tolerance on that value. The first three bands (closest together) gave the value of the resistance in ohms. The band at the end of the resistor indicated the first significant digit (n1) and the next band indicated the second digit (n2). The third band indicated the number of zeroes following these two digits (n3). The tolerance was determined from the fourth band. The bands are color codes as follows.

1st Digit	2nd Digit	Multiplier	Tolerance
0	0	0.01	10 %
1	1	0.1	5 %
2	2	1	1 %
3	3	10	2 %
4	4	100	0.5 %
5	5	1k	0.25 %
6	6	10k	0.1 %
7	7	100k	0.05 %
8	8	1M	
9	9	10M	

2) Identification of Capacitance

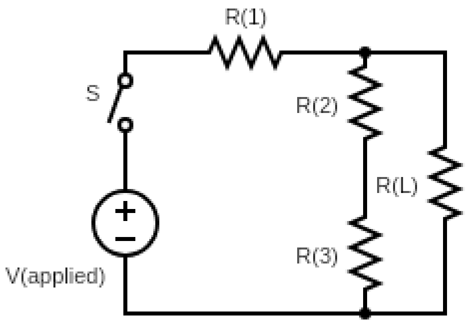
The three numbers printed on the capacitor were used to identify its capacitance value. The first two digits gave the first and second significant digits respectively. The third digit was multiplied to the former as a multiplier. The tolerance value of the capacitor was determined through a letter symbol. The digit to multiplier mapping and the letter symbol to tolerance mapping are given in the following tables.

Letter Symbol	Tolerance of Capacitor
D	+/- 0.5 pF
F	+/- 1 %
G	+/- 2 %
H	+/- 3 %
J	+/- 5 %
K	+/- 10 %
M	+/- 20 %
P	+/- 100 % , - 0 %
Z	+/- 80 % , - 20 %

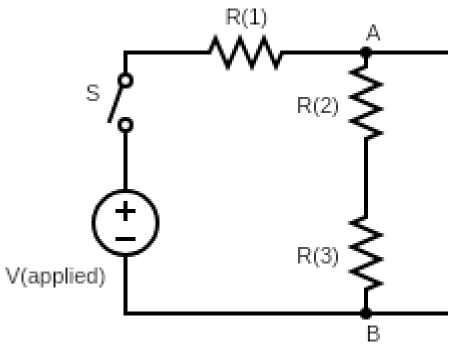
Third Digit	Multiplier (this times the first two digits give you the value in pico-Farads)
0	1
1	10
2	100
3	1,000
4	10,000
5	100,000
6 not used	-
7 not used	-
8	0.01
9	0.1

3) THEVENIN'S THEOREM

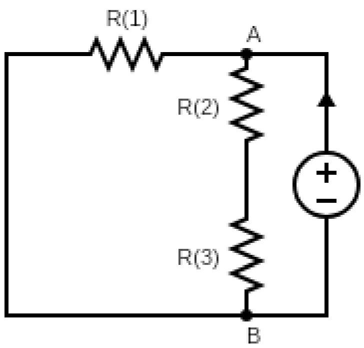
- The following circuit diagram was considered. For specific values of R_1, R_2, R_3 and R_L the values of load current I_L and potential drop V_L were measured and then verified to the values calculated through Thevenin's Theorem.



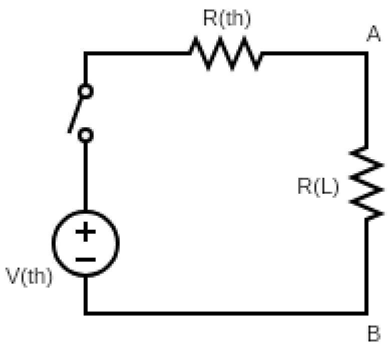
- The resistor R_L was removed and the switch S was closed. Potential difference was measured across the two terminals A and B, between which the load resistance was previously connected. The potential difference was called V_{th}.



- Now the voltage source was shorted (replaced by a wire) and another voltage source is connected between the terminals A and B.



- The input voltage is divided by the current produced by the voltage source in the circuit. The value was recorded as R_{th}.
- Same connections as in the circuit of step 1 were made. The current through the load resistor and the potential drop across it were measured and recorded.
- Values for the same parameters were calculated for the following circuit using Ohm's Law. The values were noted and compared with the measurements made in the last step.



OBSERVATION:

- IDENTIFICATION OF RESISTANCES THROUGH COLOR BANDS

S. No.	1st Band Colour	2nd Band Colour	3rd Band Colour	4th Band Colour	Resistance (in Ω)	Tolerance	Value of Resistor (in Ω)
01					250	2 %	250 ± 2%
02					6400	5 %	6400 ± 5%
03					7000	0.5 %	7000 ± 0.5%

- IDENTIFICATION OF CAPACITANCES THROUGH PRINTED CODES

S. No.	Code Printed	Capacitance Value (in pF)	Tolerance Value	Value of Capacitor (in pF)
01	415J	41 x 100,100 = 41×10^4	5%	$41\times10^4 \pm 5\%$
02	672K	67 x 100 = 67×10^2	10%	$67\times10^2 \pm 10\%$
03	154H	15 x 10,000 = 15×10^4	3%	$15\times10^4 \pm 3\%$

- VERIFICATION OF THEVENIN'S THEOREM

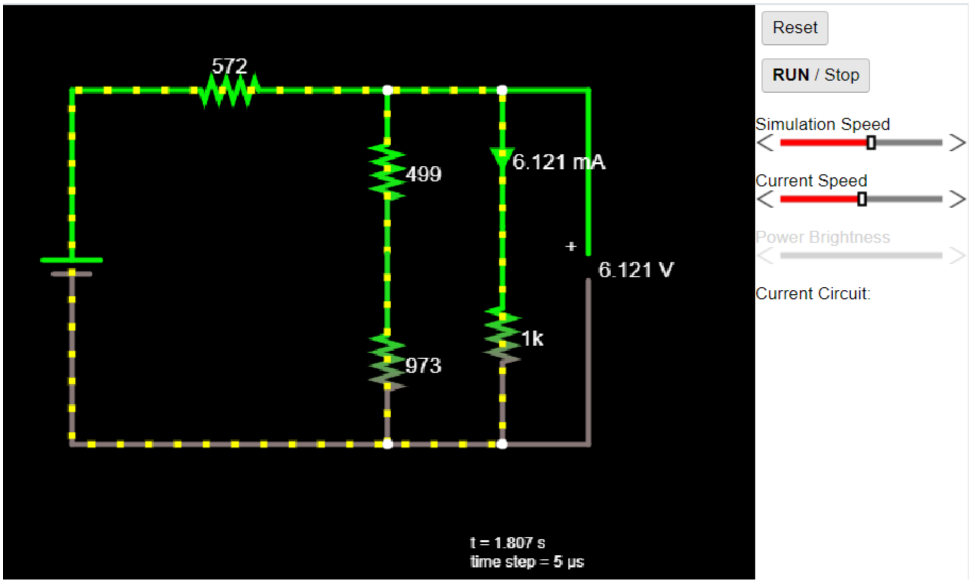
R_1 (in Ω)	R_2 (in Ω)	R_3 (in Ω)	R_L (in Ω)	R_{th} (in Ω)	V_{th} (in V)	$I_{L\text{-measured}}$ (in A)	$V_{L\text{-measured}}$ (in V)
572	499	973	1000	411.93	$V_A - V_B = 8.642$	6.121×10^{-3}	6.121

Calculations on the Thevenin equivalent of the original circuit :-

Using Kirchhoff's Voltage Loop Rule, $\mathbf{V_{th} + I_L R_{th} + I_L R_L = 0}$

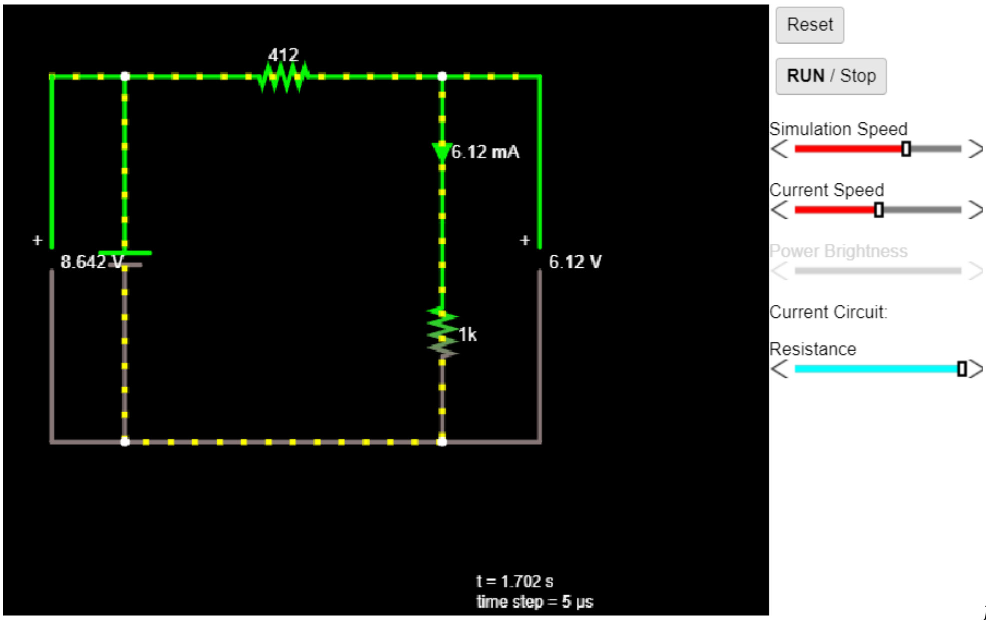
$$| I_L | = \frac{V_{th}}{R_{th} + R_L} = \frac{8.642}{411.93+1000} = 6.121 * 10^{-3}\ A$$

$$| V_L | = I_L * R_L = 6.121 * 10^{-3} * 1000 = 6.121\ V$$



from Falstad

The values of load current and load voltage for the original circuit as used in the procedure.



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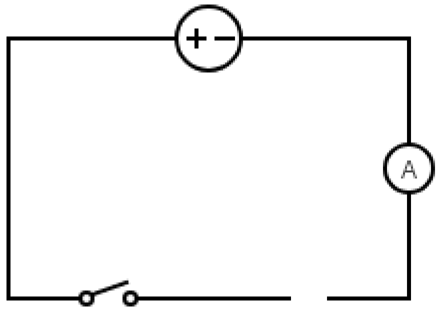
The values of load current and load voltage for the Thevenin's equivalent of the original circuit.

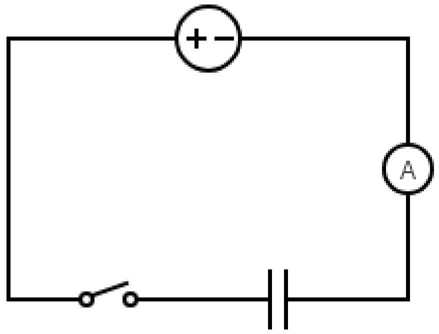
DISCUSSION:

1) Consider the set up like the one at the side. What will happen when the switch is closed?



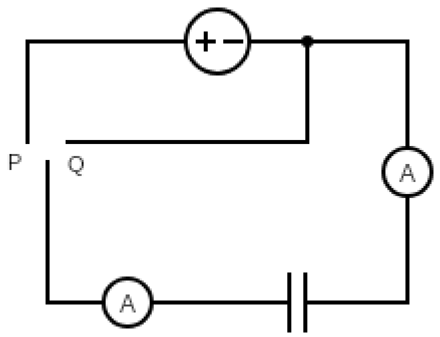
The ammeter will show a zero reading because the circuit is open even when the switch is closed.

2) Now let us place the large metal plate at each of the connectors a few millimetres apart. What will happen when the switch is closed?



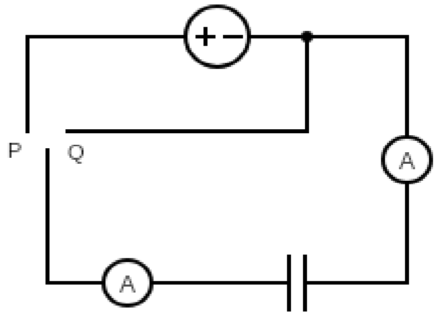
The ammeter will flick on one side and come back to zero. Assuming that the capacitor is initially uncharged, current will flow in the circuit as soon as the switch is closed. If the circuit has negligible resistance, the time constant for the charging of capacitor will be extremely small and current will quickly come back to zero.

3) Let us extend by placing a galvanometer on both sides of the capacitor and using a two-way switch. What will happen when the switch is connected to P?



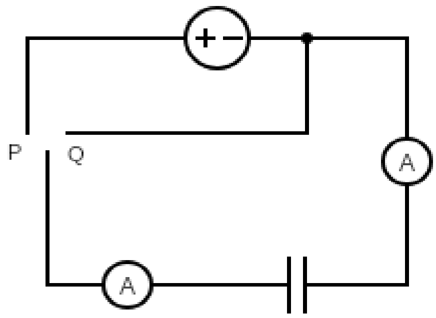
Both the ammeters flick briefly to the right.

4) After moving to P now the switch is moved to Q. What will happen?



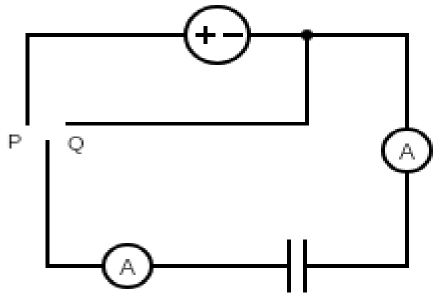
Both the ammeters flick briefly to the left because of the discharging of capacitor.

5) Instead of moving to P the first time ,if the switch is first moved to Q .
what will happen?



Neither of the ammeters move assuming that the capacitor is initially uncharged.

6) The behaviour of the ammeter needles in the previous experiment suggests that a current flow firstly one way ,then the other as the switch is moved from P to Q.
What does this suggest?



This suggests that equal charge flows off one plate and onto the other.

CONCLUSION:

- Identified the values of resistances of resistors from the colour of the bands printed on them.
- Identified the values of capacitances of capacitors from the code printed on them.
- Verified Thevenin's Theorem for a circuit by comparing the measured load parameters and the calculated load parameters.