People’s Democratic Republic of Algeria

Ministry of Higher Education and Scientific Research

Mohamed Boudiaf University of M'sila

Faculty of Sciences

Common Trunk of Matter Sciences

1st year - 2nd semester

Practical works - Physics 2

3rd Practical Work

Charging and Discharging of Capacitor

Experiment date: ………/………/……………

Corrector professor : ……………………………………………

Report prepared by :

First name	Family name	Group	Sup-group	Preparation mark	Final mark
				/5,00	/20,00
				/5,00	/20,00
				/5,00	/20,00
				/5,00	/20,00
				/5,00	/20,00
				/5,00	/20,00
				/5,00	/20,00

Academic year : 2023/2024

1- Purpose of the experiment

The aim of this experiment is to study the charge of a capacitor over time as well as discharge and determine its capacity.

2-Notions and preparation work

2-1- Charging of a capacitor

Given the setup of the opposite figure, initially the capacitor is discharged. We power the circuit «Switch in position 1 ». The capacitor begins to charge. By applying Kirchhoff's law, which says that the sum of voltages in a circuit is zero.

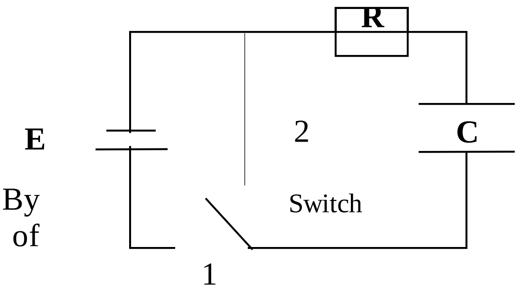

Figure-1

$$\sum_i U_i = 0 \Rightarrow E = Ri + \frac{1}{c}\int i dt$$

Or the charge « Q » of a capacitor is linked to the potential difference by the following relation

$$dQ = C\, dU_C ,$$

and the courant i to the quantity of electricity (or charge) by the relationllowing relation:

$$i = \frac{dQ}{dt}$$

The first relationship is written as a function of the output voltage U_C «U_c as follows:

$$E = RC\frac{dU_C}{dt} + U_C \Rightarrow \frac{E}{RC} = \frac{dU_C}{dt} + \frac{U_C}{RC}$$

a- Show that under the following initial conditions, $t = 0$; $U_C = 0$, that the voltage at the terminals capacity is the solution of above differential equation , and is written in the form :

$$\boldsymbol{U_C(t) = E(1 - e^{-t/RC})} \quad \text{and} \quad \boldsymbol{i(t) = \frac{E}{R} e^{-t/RC}}$$

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b- Draw the curve of $U_C = f(t)$ and the tangent to the curve for the coordinates of the origin (figure-2).

2-2- Discharge of a capacitor

a- The capacitor being charged, we will disconnect the voltage source leaving the discharge to take place through the resistor R "Switch in position 2".

b- Show that in the initial condition; $t = 0$; $U_C = E$ that the voltage at the terminals capacitor is the solution of above differential equation $(E = 0)$, and is written in the form :

$$U_C = E.e^{-\frac{t}{RC}} \Rightarrow i(t) = -\frac{E}{R}e^{-\frac{t}{R.C}}$$

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c- Draw the curve of $U_C = f(t)$ (figure-3).

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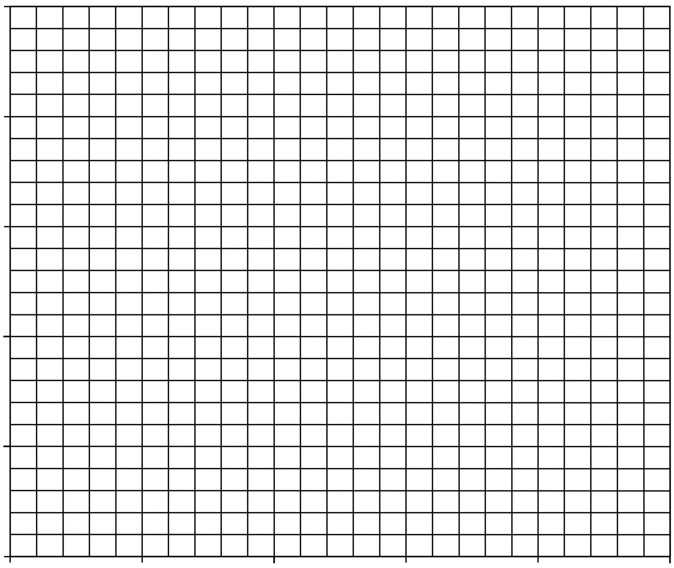

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Abscissa scale

— s

Ordonate scale

— V

Figure - 2

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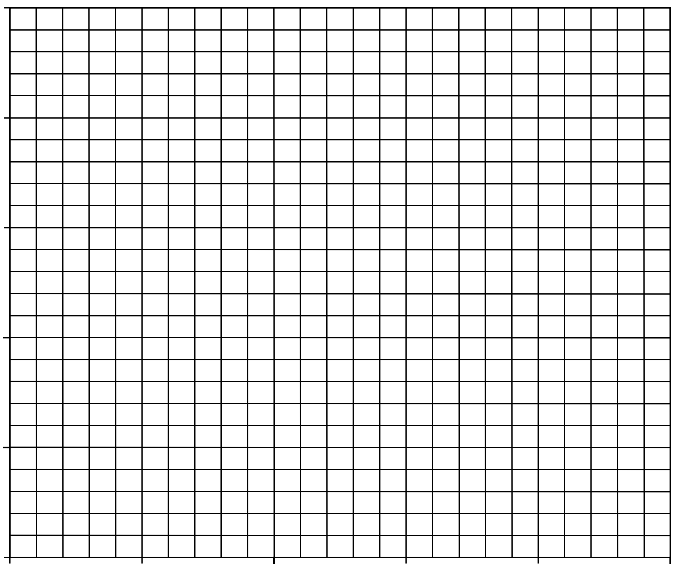

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Abscissa scale

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Ordinate scale

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Figure -3

3-Practical work

3-1- Charge of a capacitor

Before connecting the capacitor, make sure it is discharged by short-circuiting it.Perform the setup in figure-1 with the switch in position 1 for resistance « $R=3.3M\Omega$ » and a capacitor with capacity « $C=2\ \mu F$ ».

Start counting time with a stopwatch simultaneously with powering the circuit with a DC voltage source $E=8$ V.

Read the voltage of the terminals capacitor each« 05 seconds ».

Record the values in the following table :

t (s)	00	05	10	15	20	25	30	35	40	45	50
U_C (Volt)											

a- Plot the voltage $U_C = f(t)$ (figure-4).

b- Plot the tangent to the origin and determine the time constant $\tau = RC$; the abscissa of the point of intersection of this tangent with the load limit voltage. $\tau =$ .....……

c- From the time constant ensure the value of *C*. *C*=... .... *µF*

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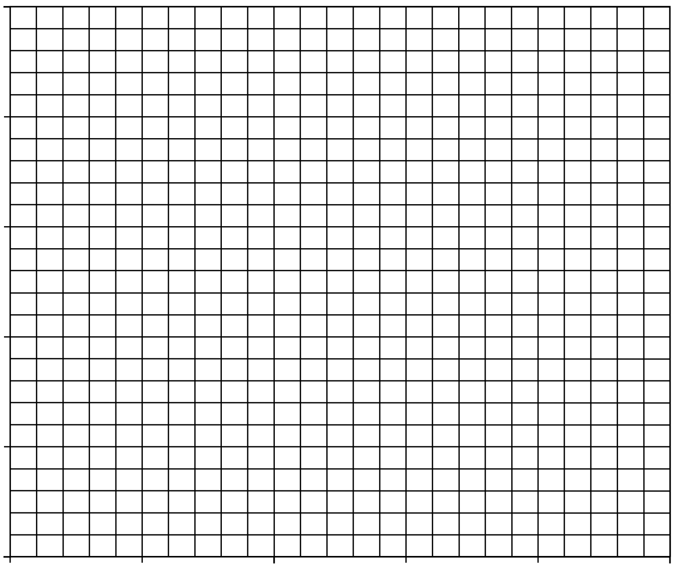

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Abscissa scale

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Ordinate scale

— ;.............V

Figure - 4

<u>3-2- Discharge of a capacitor</u>

In the case of charging the capacitor being charged, we will disconnect the voltage source while letting the discharge take place through the resistance R «Switch in position 2 ».

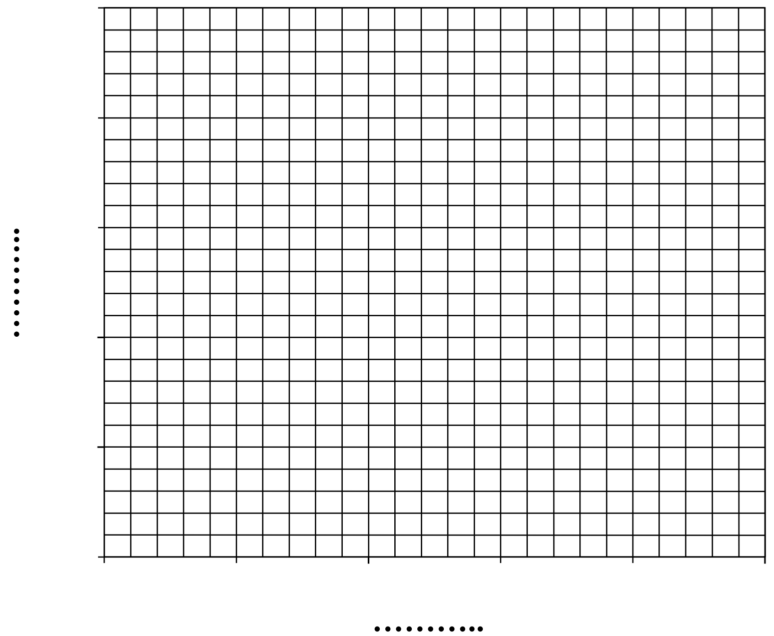
Start counting time with a stopwatch simultaneously when disconnecting power from the circuit.

Read the voltage of the terminals capacitor each« 05 seconds ».

Record the values in the following table:

t (s)	00	05	10	15	20	25	30	35	40	45	50
U_C (Volt)											

a- Plot the tension $U_c=f\ (t)$ (figure-5).
b- Plot the tangent to the discharge point and determine the time constant $\tau=RC$;the abscissa of the point of intersection of this tangent with the load limit voltage. τ=.......
c- From the time constant ensure the value of *C*. *C*=... .... *µF*



Abscissa scale
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Ordinate scale
— ;............V

Figure - 5

3-3- Association of capacitors in parallel

Perform the experimental setup in figure-6 for resistance « *R=3.3MΩ* » and two capacitor of capacities « C_1=1 *µF ;* C_2=1 *µF* ».
Start counting time with a stopwatch simultaneously with powering the circuit with a DC voltage source *E* =8 V.
Read the voltage of the terminals capacitor each 05 seconds.
Record the values in the following table :

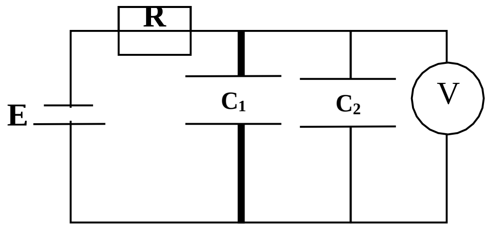

Figure-6

t (s)	00	05	10	15	20	25	30	35	40	45	50
U_C (Volt)											

a-Plot the voltage $U_c = f\,(t)$ (figure-7).
b-Plot the tangent to the discharge point and determine the time constant $\tau=R.C$
the abscissa of the point of intersection of this tangent with the load limit voltage. τ=.......
c- From the time constant determine the value of *C*. *C*=... ....*µF.*

d- Compare this value to the equivalent value for two capacitors in parallel
$C_{eq} = C_1 + C_2$ ……………………………………………………………………………………
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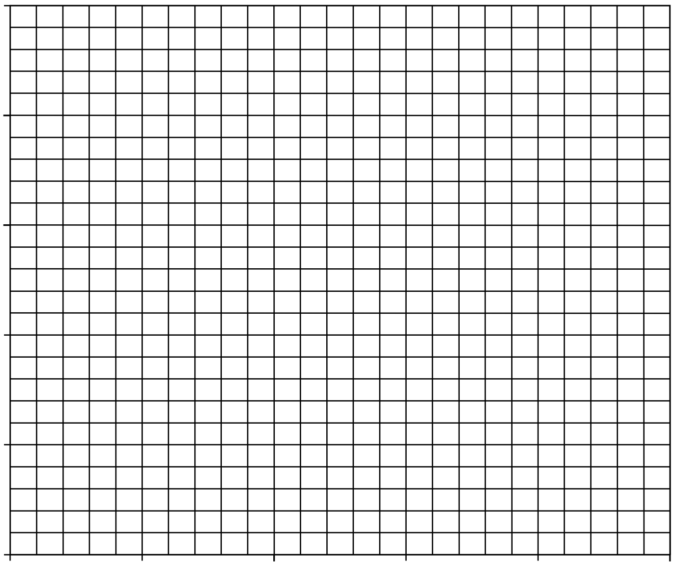

Abscissa scale
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Ordinate scale
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Figure - 7

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3-4- Association of capacitors in series

Perform the setup in figure-8 for resistance « $R=3.3M\Omega$ » and two capacitors of capacities « $C_1=6\ \mu F$; $C_2=3\ \mu F$ » and this after having discharged by short circuit. Start counting time with a stopwatch simultaneously with powering the circuit with a DC voltage source $E = 8$ V.
Read the voltage of the the terminals capacitor each « 05 seconde »
Record the values in the following table :

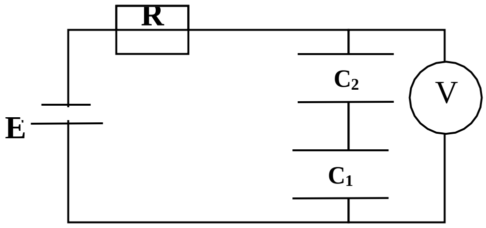

Figure-8

t (s)	00	05	10	15	20	25	30	35	40	45	50
U_C (Volt)											

a- Plot the voltage $U_c = f(t)$ (figure-9).
b- Plot the tangent to the discharge point and determine the time constant $\tau = R.C$ the abscissa of the point of intersection of this tangent with the load limit voltage. τ = ...
c- From the time constant determine the value of *C*. *C*=… …………..*µF.*
Compare this value to the equivalent value for two capacitors in series:

$C_{eq} = C_1 C_2 / (C_1 + C_2)$ ………………………………………………………………………………
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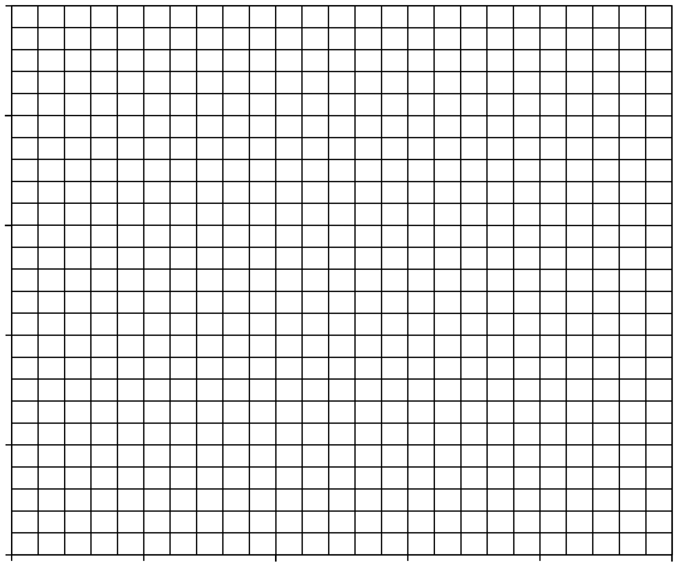

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Abscissa scale
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Ordinate scale
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Figure - 9