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وزارة التعليم العالي والبحث العلمي

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Faculty of Technology

Socle Commun (ST)

First Year (ST-REE-ING), 2nd Semester

Physics practical work II

4th Practical Work

Charging and Discharging of a Capacitor

Date:……..../……..../……..

Professor:…………………

First Name	Last Name	Group	Sub-Group	Prep Mark	Final Mark

Academic Year: 2023/2024

1- Purpose of the experiment

The objective of this experiment is to study the charging and discharging of a capacitor by measuring the potential difference (voltage) across the capacitor as a function of time.

2- Concepts and preparation work

1- Charging a capacitor

As given in the circuit of Figure 1, initially, the capacitor is discharged. We supply the circuit by turning the Switch to position 1. The capacitor begins to charge. By applying Kirchhoff's law; which says "the sum of the voltages in a circuit is zero" we found:

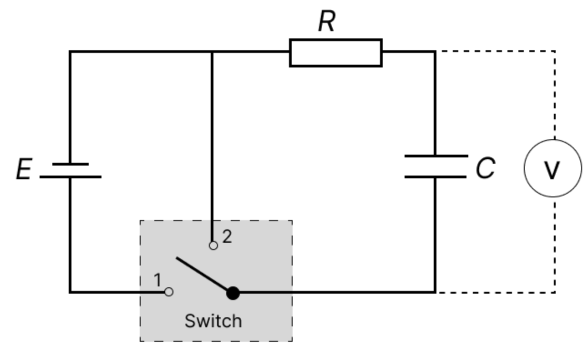

Figure 1

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

The charge *"Q"* of the capacitor is related to the potential difference by the following relation:

$$dQ = CdU_c$$

and the current *i* to the quantity of electricity (or charge) is given by the relation

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

The first relationship can be written as a function of the output voltage "*Uc*" 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, $t = 0$; $Uc = 0$, the voltage across the capacitor is the solution to the above differential equation, and is written in the form:

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

b- Plot the curve of *Uc: = f(t)* and the tangent to the curve for the coordinates of the origin (figure-2).

2-2·- Discharging a capacitor

a- The capacitor being charged, disconnects the voltage source by turning the Switch to position 2 to leave the discharge to take place through the resistance R.
b- Show that in the initial condition; ($t = 0$; $Uc = E$) that the voltage across the capacitor is the solution to the above differential equation ($E = 0$), and is written in the form:

$$U_c(t) = E.e^{-t/RC} \text{ and } i(t) = -\frac{E}{R}e^{-t/RC}$$

c- Plot the curve of $U_c = f(t)$ (figure-3)

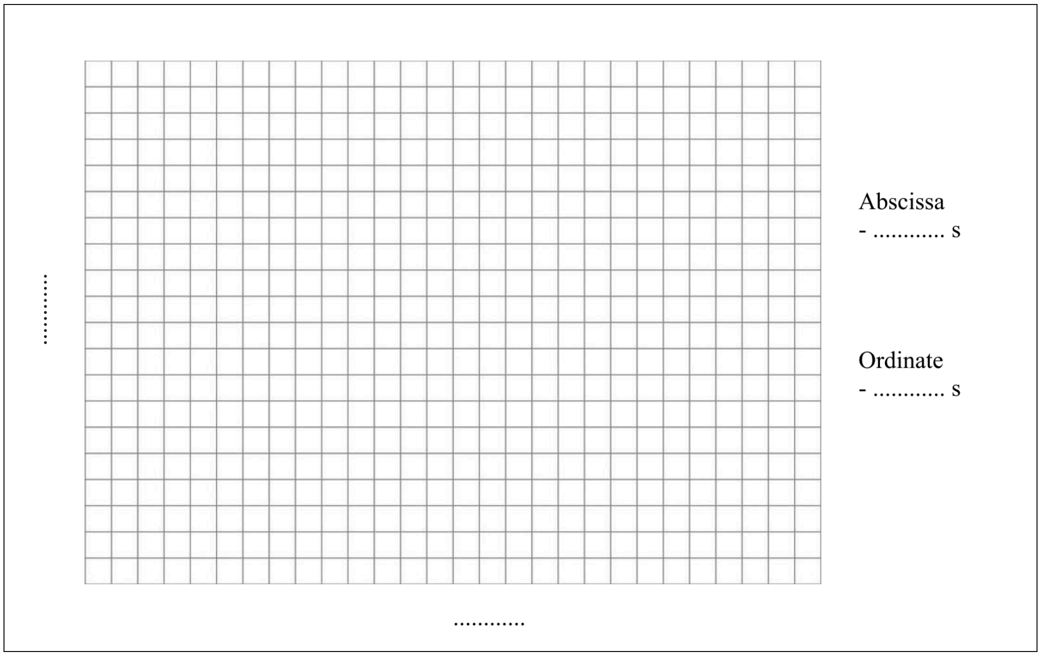

Figure 2

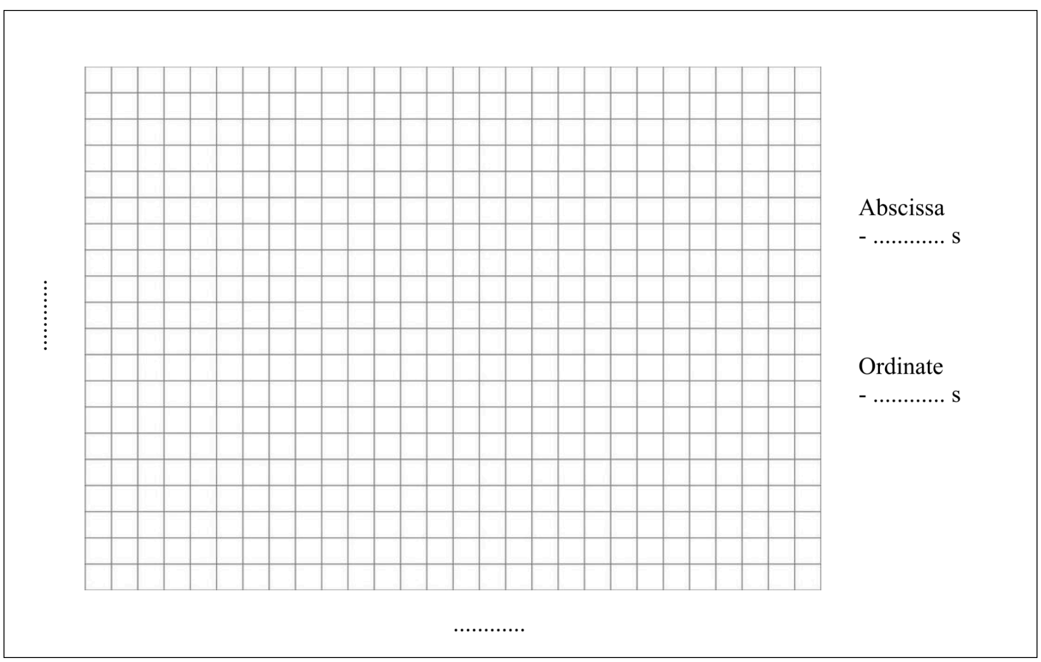

Figure 3

3. Practical Work

3.1- Charging a capacitor

Before connecting the capacitor make sure it's discharged by short-circuiting it. Perform the setup in Figure 1 and turn the switch to position 1. The resistance is equal to 3.8MΩ and a capacitor with a capacity of C=2μF starts counting time with a stopwatch simultaneously with powering the circuits with a DC voltage source *E=8V.*

Read the voltage of the capacitor terminal each 5 Seconds and record the values in the following table

t(s)	00	05	10	15	20	25	30	35	40	45	50
Uc(V)											

a- On graph paper, plot the voltage *Uc= f(t)* (figure-4).
b- Plot the tangent to the origin point and determine the time constant, $\tau = RC$; the abscissa of the point of intersection of this tangent with the limit voltage of the load $\tau =$ ….
c- From the time constant ensure the value of C. *C= …. μF*

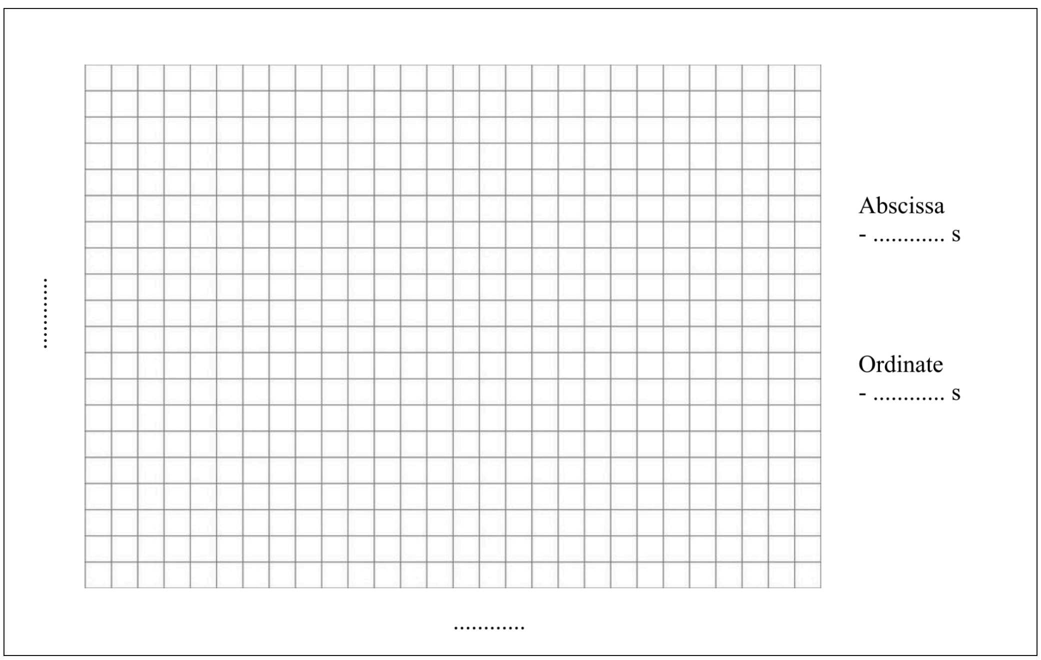

Figure 4

3.2- Discharging a capacitor

To discharge the capacitor, disconnect the voltage source by turning the switch to position 2, and start counting time with a stopwatch simultaneously with disconnecting the voltage source. the capacitor discharges over time through the resistance R, Read the voltage of the capacitor terminal each 5 seconds and record the values in the following table.

t(s)	00	05	10	15	20	25	30	35	40	45	50
Uc(V)											

a- On graph paper, plot the voltage $Uc = f(t)$ (figure-5).
b- Plot the tangent to the origin point and determine the time constant, $\tau = RC$; the abscissa of the point of intersection of this tangent with the limit voltage of the load $\tau =$ ….
c- From the time constant ensure the value of C. $C =$ …. μF

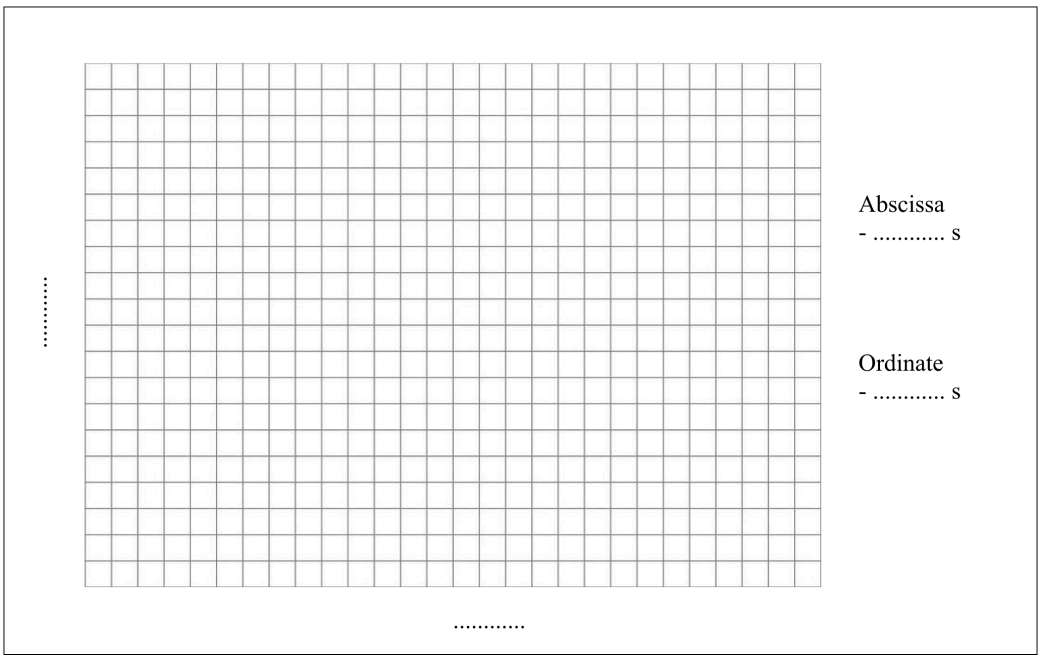

Figure 5

3.3- Combination of capacitors in parallel

Wire the circuit as shown in the following figure 6. for a resistance R = 3.8MΩ . and two capacitors of $C1 = 2\ \mu F$ and $C2 = 1\ \mu F$.

Start counting the time using a stopwatch simultaneously when powering the circuit with a DV voltage source E =8V.

Read the voltage at the capacitor terminals every 05 seconds and record the values in the following table

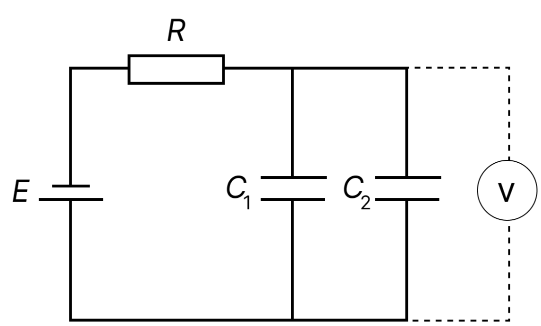

Figure 6

t(s)	00	05	10	15	20	25	30	35	40	45	50
Uc(V)											

a- On graph paper, plot the voltage *Uc= f(t)* (figure-7).
b- Plot the tangent to the origin point and determine the time constant, $\tau = RC$; the abscissa of the point of intersection of this tangent with the limit voltage of the load. $\tau =$ ….
c- From the time constant ensure the value of C. *C=* …. μF
d- Compare this value to the equivalent one of two capacitors in parallel $C_{eq} = C_1 + C_2$

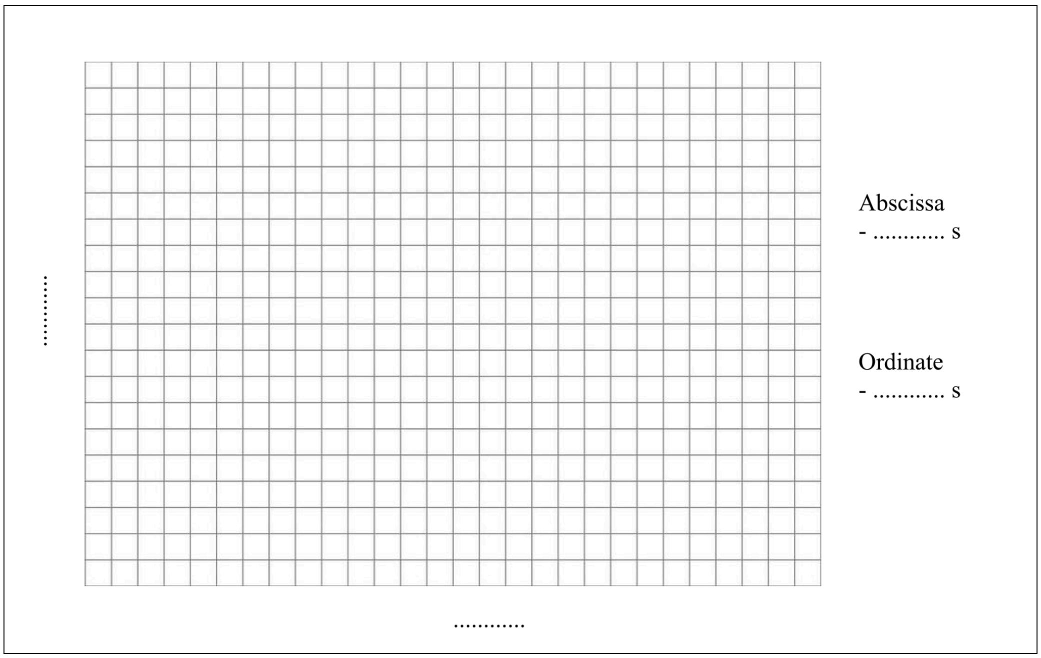

Figure 7

3.4- Combination of capacitors in series

Wire the circuit as shown in the following figure. for a resistance R = 3.8MΩ . and two capacitors of *C1 =6* μF and *C2=3uF".*

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

Read the voltage across the capacitor each 05 seconds and record the values in the following table

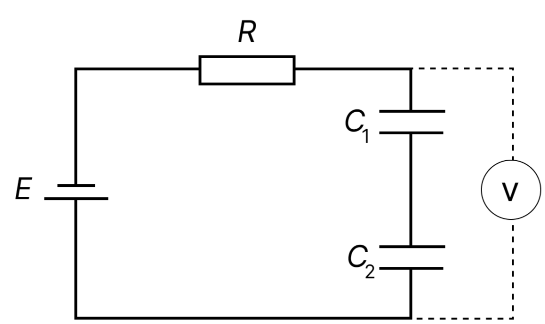

Figure 8

t(s)	00	05	10	15	20	25	30	35	40	45	50
Uc(V)											

a- On graph paper, plot the voltage *Uc= f(t)* (figure-9).

b- Plot the tangent to the origin point 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

d- Compare this value to the equivalent value of two capacitors in series $C_{eq} = C_1C_2/(C_1 + C_2)$

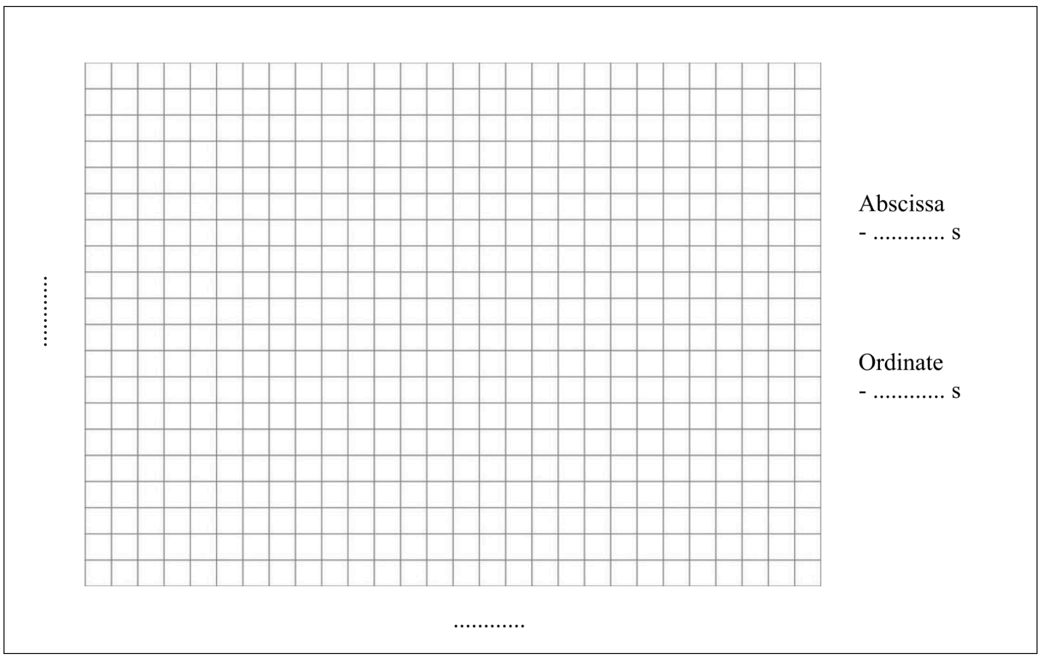

Figure 9