Pre-Lab Report

Lab section:

Name & Surname:

Table #:

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

Q1. Starting from Kirchoff's law, derive $t_{1/2} = (\ln 2)RC$ expression. **Show your derivation / formulae explicitly or NO CREDITS!** (Hint: Solve the differential equation for charge and apply boundary conditions. Do not write the solution of the differential equation directly **or no credits!)**

(2nd Question is on the next page!)

Q2. What is the meaning of half-life for an RC circuit? To measure $t_{1/2}$, which condition needs to be satisfied? **Explain in YOUR OWN WORDS and justify your answer, or no credits!**

Q3. What is an integrating circuit? Which condition needs to be satisfied to observe it? **Explain in YOUR OWN WORDS and justify your answer, or no credits!**

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Lab Report

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***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To observe and measure the effects caused by the growth and decay of currents in a capacitor.

THEORY : When you connect a capacitor and a resistor in series and apply a specific waveform, the behavior of the circuit can be understood by applying the Kirchoff's laws:

$$R\frac{dq}{dt} + \frac{q}{C} = V_{app} \,.$$

Solution of this first order differential equation depends on the applied waveform. If the applied voltage is constant, then the solution for the charge or the voltage on the capacitor is a function that increases exponentially until it reaches the maximum value. On the other hand if we apply a square wave signal, choosing a period much longer than the half-life of the RC circuit or the RC time constant,

$$t_{1/2} = (\ln 2)RC \,,$$

provides us with a waveform repeatedly displaying the discharge of the capacitor when the square wave goes to the low level or "turns off."

On the other hand, if we go to the other extreme and choose a square wave signal with a period much shorter than the RC time constant, then the voltage across the capacitor is basically the integral of the applied potential. The circuit equation above can be approximated as:

$$R\frac{dq}{dt} \approx V_{app} \Rightarrow \frac{dq}{dt} = \frac{V_{app}}{R}$$

since the voltage on the capacitor is negligible compared to the voltage across the resistance. Even though we neglect the voltage across the capacitor when determining the current passing through the RC circuit, we can still get a nonzero voltage across it.

$$V_c = \frac{q}{C} = \frac{1}{RC}\int V_{app}\,dt$$

with the approximation that $V_c << V_{app}$.

Spring 2024

APPARATUS : Oscilloscope, oscillator, resistance and capacitor boxes.

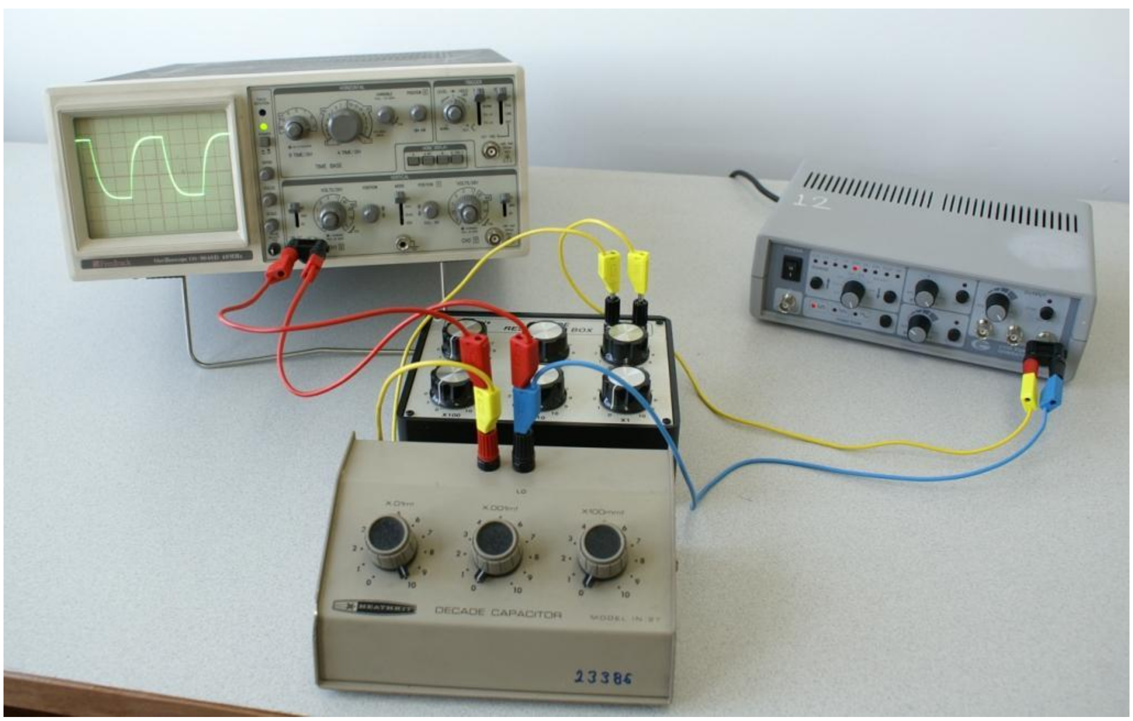
PROCEDURE :

Part 1:

1. Use 3000 Ω for *R* and 0.1 μF for *C*.
2. Calculate the true value of half-life of the RC circuit and determine the square wave frequency to set.
3. Construct your circuit and turn on your oscilloscope.
4. Adjust the controls for optimum focus, stability and trigger action.
5. From observed pattern on the oscilloscope screen, measure $t_{1/2}$.

Part 2:

1. Use the same circuit but set much higher frequency on the Square Wave Generator.
2. Draw one period of the applied square wave voltage and using the same scale draw the corresponding pattern for the voltage across the capacitor below that.
3. Show that the capacitor voltage is proportional to the integral of the applied square wave voltage.



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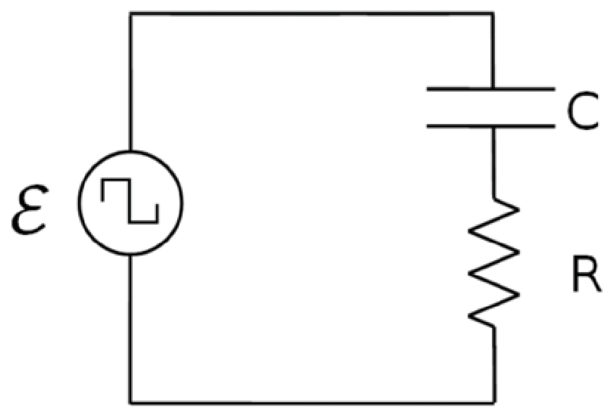
PART-1 DISCHARGING CHARACTERISTICS

Connect the circuit. Show where you should connect the oscilloscope on the circuit:



DATA GIVEN

Description	Symbol		Value	
Resistance set on the Resistance Box	*R*	=	3000 Ω	Given
Internal Resistance of the SWG	R_{SWG}	=	600 Ω	Given
Capacitance	*C*	=	0.1 μF	Given

Set *R* on resistance box and construct the circuit!

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CALCULATIONS

Description	Symbol	Calculation (show each step)	Result
Total Resistance	R_T	=.	. . . .
True Value of the Half-Life	$t_{1/2TV}$	=	. . . .
Period	T	= 20 $t_{1/2}$=.	. . . .
Frequency of the SWG	f_{SWG}	=	. . . .

Set f_{SWG} on signal wave generator and connect the circuit!

DATA to be taken on Oscilloscope

Description	Symbol	Result
[VOLT/DIV]		= . . . .
[TIME/DIV]		= . . . .
Half-Life in cm	$t_{1/2EV}$ (cm)	= . . . .

RESULT

Description	Symbol	Calculation (show each step)	Result
Half-Life in sec	$t_{1/2EV}$	=	. . . .

% Error for $t_{1/2}$:

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PART-2: AN INTEGRATING CIRCUIT

Set the frequency of the SWG to f_{SWG}= **20 kHz**. R_T and C values should be the same as Part-1.

Draw the Capacitor Voltage Waveform:

[VOLT/DIV]= . . . . [TIME/DIV]= . . . .

Draw the applied Square Waveform: (Conenct the Oscilloscope directly on SWG)

[VOLT/DIV]= . . . . [TIME/DIV]= . . . .

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From the Graphs for the chosen t_1 and t_2, read the following data:

Symbol & Formula		Calculation (show each step)	Result
$V_c = V_{c2} - V_{c1}$	=	. . . .	. . . .
$\int_{t_1}^{t_2} V_{app}\,dt$	=	. . . .	. . . .
		. . . .	
$(\frac{1}{R_T C})_{TV}$	=	. . . .	. . . .
		. . . .	
$(\frac{1}{R_T C})_{EV} = \frac{V_{c2} - V_{c1}}{\int_{t_1}^{t_2} V_{app}\,dt}$	=	. . . .	. . . .
		. . . .	
% Error for (1/*RC*)	=	. . . .	. . . .

Consult to the resources for this experiment from PHYS LAB Website:

PHYL201 Intro

Presentation #5

PHYL201 Lab Book