This is a Class 1 exam

Lebanon Evangelical School for Boys and Girls

Lighting the fires that burn for eternity

Louizeh - Baabda

Lebanon Evangelical School

for Boys and Girls — Loueizeh - Baabda

Stage Exam 02

19DEC2022

Do NOT write in this box. Your MARK will be placed here.

Subject :	Physics	
Class :	12M	
Teacher :	Mr. Ali Moukalled	
Duration :	1 hour	
Your name :		*Time taken to complete exam*
Your Class :		
Exam Room :		
How many sheets, including cover sheet :		

- Do not open this paper until the teacher in charge instructs you to do so.
- The most important thing to remember in taking an exam is NEVER PANIC.
- If you are caught cheating in this exam, you will be awarded zero for ALL exams that are taken on this day.

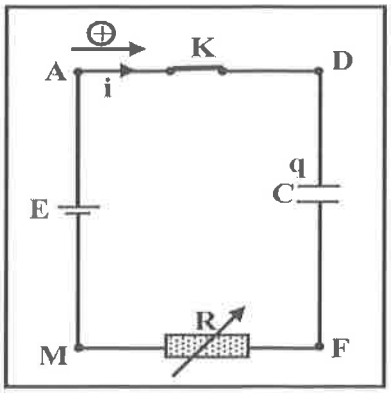
EXERCISE 1 (10points)

Effect of the resistance on the charging of a capacitor

The aim of this exercise is to study the effect of the resistance of a resistor on the charging of a capacitor. For this aim, we set-up the circuit of the adjacent document that includes:

- a capacitor, initially uncharged, of capacitance $C = 4\mu F$;
- a resistor of adjustable resistance R;
- an ideal battery of voltage $U_{AM} = E$;
- a switch K.

We close the switch at $t_0 = 0$, and the charging process starts.



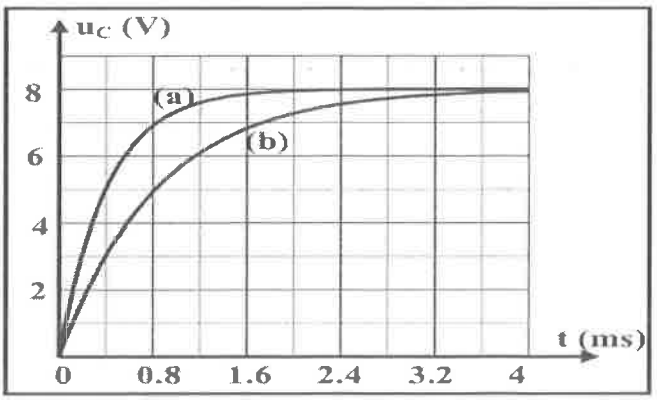
1. Theoretical Study

1. Derive the differential equation that describes the variation of the voltage $u_{DF} = u_C$ during the charging of the capacitor.
2. The solution of this differential equation has the form of : $u_C = A + Be^{Dt}$. Determine the constants A, B and D in terms of E, R and C.
3. Verify that the capacitor becomes practically fully charged at $t = 5RC$.
4. Indicate the effect of the resistance of the resistor on the duration of the charging of the capacitor.

2. Experimental Study

We adjust R to two different values R_1 and R_2; an appropriate device allows to trace, for each value of R, the voltage u_C as a function of time.

- curve (a) corresponds to $R = R_1$.
- curve (b) corresponds to $R = R_2$.

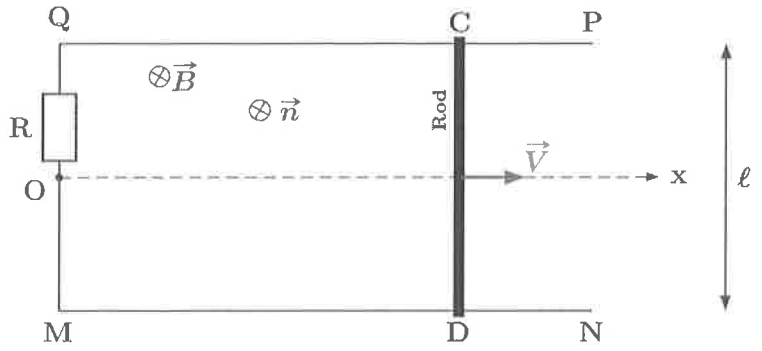


1. Using the curves aside :
   (a) specify the value of E;
   (b) specify, without calculation, whether the value of R_2 is : equal to, greater than, or less than the value of R_1;
   (c) determine the values of R_1 and R_2.
2. The capacitor is fully charged, the electric energy stored in the capacitor is W_C.
   (a) Is the value of W_C affected by the resistance of the resistor? Justify.
   (b) Deduce the value of W_C.

Turn the page

EXERCISE 2 (10points)

A resistor of resistance $\mathbf{R = 2.2\Omega}$ is connected between two long parallel conducting rails QP and MN. The circuit is placed in the horizontal plane in the region of uniform magnetic field $\vec{B}$ of magnitude $\mathbf{B = 0.2T}$ and of direction perpendicular to the plane of the conductors. A horizontal straight metal rod CD of length $\ell = \mathbf{10cm}$ is moving between the two conductors with a horizontal velocity $\vec{V}$ of constant speed $\mathbf{V = 0.5m/s}$, under the action of a horizontal constant force $\vec{F}$ of magnitude F. The below figure is a diagram of the top of view of the experiment.
The friction force $\vec{f}$ is directed opposite to $\vec{V}$ and has a constant magnitude of $\mathbf{2 \times 10^{-5}N}$.
Neglect the resistance of the rails and assume that the internal resistance of the rod is $\mathbf{r = 0.3\Omega}$.



1. Specify the chosen positive sense of the circuit.
2. Indicate the name of the phenomenon that takes place in the above circuit. Apply Lenz's law to determine the direction of the induced current in the circuit.
3. Determine the expression of the magnetic flux crossing the closed circuit in terms of B, ℓ, V and the time t, knowing that at $\mathbf{t_0 = 0}$, the flux crossing the circuit is zero.
   Hint: In a Uniform Rectilinear Motion, $x = Vt + x_0$
4. Calculate the emf "e" induced in the circuit.
5. Deduce:
   (a) the direction of the induced current. Compare this direction to the determined in part 2.
   (b) that the algebraic value of the induced current is -4mA.
6. Calculate the potential difference $\mathbf{u_{QM}}$ across the resistor R.
7. (a) Calculate the magnitude of laplace's force acting on the rod.
   (b) Apply Newton's first law to determine the magnitude of the force $\vec{F}$.

GOOD LUCK

12M

Exercise 1

1) Theoretical Study

1) $E = u_c + u_R$

$E = u_c + Ri$

$E = u_c + RC\frac{du_c}{dt}$

$\frac{du_c}{dt} + \frac{1}{RC}u_c = \frac{E}{RC}$ (1)

2) $u_c = A + Be^{Dt}$

$\frac{du_c}{dt} = BDe^{Dt}$

Replace u_c & $\frac{du_c}{dt}$ in the differential Equation

$A = E$ $\quad D = -\frac{1}{RC}$ (1)

$B = -E$

3) $u_c = E(1 - e^{-t/RC})$

at $t = 5\tau = 5RC$

$u_c = 0.99E$

$u_c \simeq E$ (1)

4) With higher Resistance, the charging time increases, $\therefore$ the charging becomes slower. (0.5)

(1)

Experimental study

1) a) $E = 8V$ (0.5)

b) At $t = \tau$, $u_c = 0.63E$

+c) $= 0.63(8)$ (1)

$= 5V$

Graphically $t = \tau_1 = 0.4ms$ $\tau_2 = 0.8ms$

$R_1 = \frac{\tau_1}{C} = \frac{0.4 \times 10^{-3}}{4 \times 10^{-6}}$, $R_1 = 100\Omega$

$R_2 = 200\Omega$ (1)

b) $u_{c(b)} < u_{c(a)}$ b slower

$R_2 > R_1$ (1)

2) a) $W_c = \frac{1}{2}CE^2 \Rightarrow$ No independent of R

b) $W_c = \frac{1}{2}(4 \times 10^{-6})(8)^2$ (1)

(1)

$W_c = 1.28 \times 10^{-4} J$

Exercise 2:

1. $\vec{n}$ is directed inwards, then the circuit is oriented positively in the clockwise sense. (1)

2. The phenomenon that takes place in the above circuit is: electromagnetic induction.
According to lenz's law, the created laplace force acting on the rod is directed horizontally to the left to resist the motion of CD to the right.
According to the right hand rule, the induced current flows from D to C through the rod. (2)

3. $\phi = S\ \vec{B}.\vec{n} = BS\cos\alpha = BS\cos(0) = B\ell x$
Since $\vec{v}$ is constant, then $x = vt + x_0$
$x_0 = 0$; therefore $\phi = B\ell vt$ (1)

4. $e = -\frac{d\phi}{dt} = -B\ell v = -(0.8)(0.5)(0.1)$ (1)
then, $e = -0.01\,V$

5. a. $e<0$, so $i<0$ (since $ei>0$), then the direction of the induced current is opposite to the chosen positive sense, so i is directed from D to C through the rod (2)
The directions are the same

b. $i = \frac{e}{R+r} = \frac{-0.01}{2.2+0.3} = -4\times10^{-3}\,A$; therefore $i = -4\,mA$ (1)

6. $U_{MQ} = iR = -4\times10^{-3}(2.2) = -8.8\times10^{-3}\,V$
therefore $U_{QM} = 8.8\times10^{-3}\,V$ (0.5)

7. a. $f_L = |i| \ell B \sin\beta$ ($\beta = 90°$ is the angle between the direction of i in the rod and that of $\vec{B}$)

$f_L = (4\times10^{-3})(0,1)(0,2)\sin(90°)$

then, $f_L = 8\times10^{-5}$ N

0.5

b. The external forces acting on the rod are:

- the weight $m\vec{g}$
- the normal forces $\vec{N_C}$ and $\vec{N_D}$
- the friction force $\vec{f}$
- Laplace's force $\vec{F_L}$
- the applied force $\vec{F}$

1

Newton's first law: $\sum \vec{F}_{ext} = \vec{0}$ ($\vec{V}$ is constant)

then $m\vec{g} + \vec{N_C} + \vec{N_D} + \vec{f} + \vec{F_L} + \vec{F} = \vec{0}$

Projecting the vectors along the direction of the motion of the rod gives:

$0 + 0 - 2\times10^{-5} - 8\times10^{-5} + F = 0$

Therefore, $F = 10^{-4}$ N