Class : Third Secondary- General Sciences | Duration : 180 minutes
Subject : Physics | Mark : 27.5 points

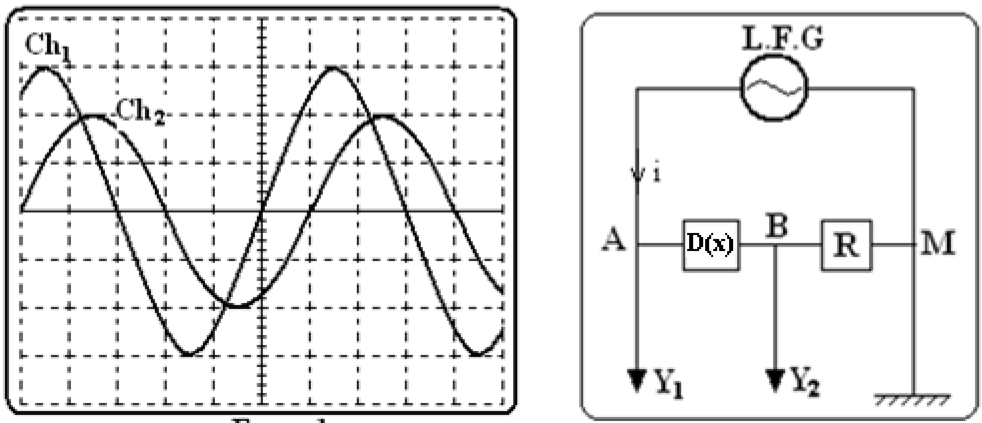
FINAL EXAM

Non programmable Calculators are allowed

First exercise: (6points)

Determination of an unknown component

In order to identify an electric component D and find its characteristic quantity$[x]$, we connect it in series with a resistor R=100Ω across a LFG delivering the voltage $u_G = 12\cos(1oo\pi t)$ (**u** in volt, **t** in sec).
This unknown component D may be a resistor (x is then its resistance) or a capacitor (x is then its capacitance) or a coil of negligible resistance (x is then its inductance). When the channels Y_1 and Y_2 of the oscilloscope are connected as shown, we obtain the waveforms shown in figure 1.
The vertical sensitivity on the channel Y_2 is 3v/div.



Fgure 1

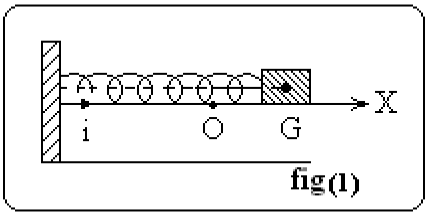
1) Calculate the vertical sensitivity on the channelY_1.
2) Which waveform leads the other? And by what angle? Deduce the nature of the unknown component.
3) Write the expression of the current **i** in the circuit as a function of time and deduce the average power consumed in the circuit.
4) Determine $u_D = u_{AB}$ in terms of x and t. Then using the principle of addition of voltages, write the relation among u_G , u_D, and u_R. Using a particular value of t calculate x.
5) It is required to add a component in series with the above circuit that would make the effective current in the circuit attain a maximum value (Resonance current). Which of the following choices will do: (giving all the necessary explanations)
   - A resistor of resistance R'
   - A coil of inductance L' and of negligible resistance.
   - A capacitor of capacitance C'.

   Calculate then the maximum effective current and the characteristic value of the chosen component.

Second exercise: (7points)

Mechanical Oscillator

An elastic horizontal pendulum is formed of a solid of mass m=250g and a spring of stiffness k=10N/m. To study the motion of the center of mass G of the solid, an axis is chosen whose origin O coincides with the equilibrium position G_0 of the solid. $\overline{OG} = x$



fig(1)

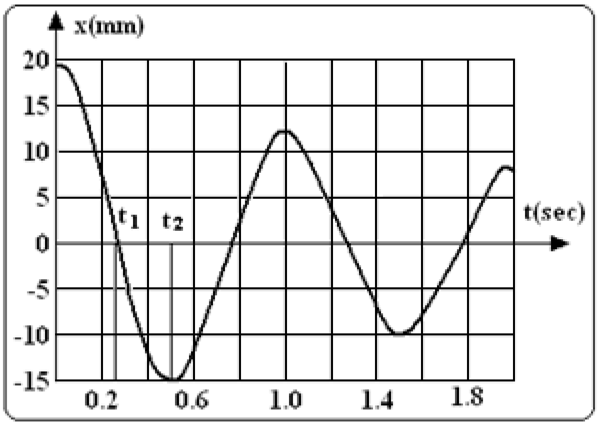
A) Friction is negligible.

Displace the solid 2cm from its equilibrium position and release it without initial velocity at t=0.

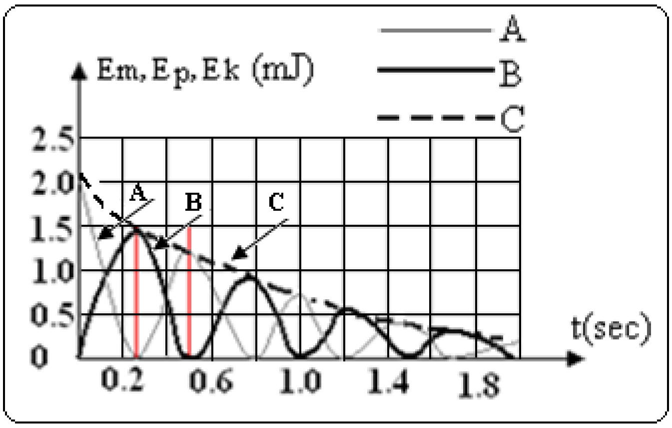
1- What is the mode of the oscillations formed?
2- Establish the differential equation that described the motion of G.
3- Knowing that X=$X_m\cos(\omega_0 t + \varphi)$ is a solution of the differential equation, determine ω_0 in terms of k and m.
4- Determine the numerical values of X_m, ω_0 and φ. Deduce the proper period T_0 of the motion.

B) Friction is not negligible.

In reality the force of friction isn't negligible and equals to $\vec{f}$ = -$k_1\vec{V}$ where k_1= cst>0. The tracing of the position of G and the energies of the system (pendulum,Earth) as a function of time gives the following figures:



figure(2)



figure(3)

1) What is the mode of oscillations of the pendulum?
2) Using figure (2), determine the pseudo-period T of the oscillations, and compare it with T_0. Justify.
3) Using figure (3), identify graphs A, B and C. find the period T_1 of A & B. Compare it with T.
4) Two instants t_1 and t_2 are shown on figure (2). Which of the two speeds corresponds to?
   a. Maximum speed, b. zero speed? Justify.
5) Determine the variation of the ME of the pendulum between the two instants $t_0 = 0$ and $t = 1.4s$.
6) Calculate the work done by friction between these two instants.

C) A driving force $\vec{F}$ is applied on G so that the motion of G is described by X=$X_m\cos(\omega_0 t + \varphi)$ as in part A.

1) What is the mode of oscillations of the pendulum?

2) Determine $\overrightarrow{F_1}$ as a function of k_1 and t.
3) Determine the average power given to the pendulum between $t_0 = 0$ and $t = 1.4s$.

Third exercise: (7points)

The nuclide $^{108}_{47}Ag$ is β^- emitter.

1. a) Write the equation for this nuclear reaction, specifying the rules used.
   b) Specify the symbol of the resultant nucleus and give its nuclear composition. Using the following table:

$_{46}Pd$	$_{47}Ag$	$_{48}Cd$

   c) Calculate the energy liberated by the above reaction, knowing that:
   $m_{^{108}_{47}Ag} = 107.9865u,\ m_{^{108}_{48}cd}$=107.9615u, , $m_{^{108}_{46}pd}$=107.9050u, $m_{\ ^{0}_{-1}e}$=5.5× $10^{-4}u$
   1u = 931.5Mev/c^2 .
2. a) Write the formula representing the law of radioactive decay (N in terms of t) and describe the meaning of each term. No need to demonstrate the formula.
   b) Define the radioactive period T.
   c) Establish the expression of the radioactive constant λ as a function of T.
   d) The variation in activity of a sample of $^{108}_{47}Ag$ is studied over time.
   Activity A is defined by A= $-\frac{dN}{dt}$ and expressed in Becquerel's.
   (One Becquerel corresponds to one disintegration per second).
   i) - Derive activity A as a function of time.
   - Complete the following table:

T(min)……………	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5
A(Bq)…………….	90	73	63	52	44	39	33	29	24	21	18
lnA……………….											

   ii) Draw the representative curve lnA = f(t),
   Scales: Abscissa: 1cm≘0.5min;
   Ordinate: 1cm≘0.5.
   iii) Using the above graph, Determine the radioactive constant λ of $^{108}_{47}Ag$.
   Deduce its radioactive period.
   e) What is the number of nuclei initially present in this sample?

Fourth exercise: (7.5points)

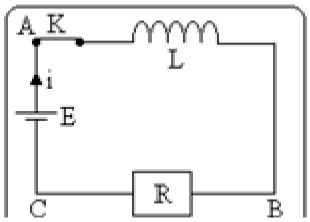
Transient state – Steady state

A- (R,L) series circuit

In the circuit of figure 1, L=1H, R=1KΩ and E=10V.

At the instant $t_0 = 0$, we close the switch K. At the instant t, the circuit carries a current i. An oscilloscope, conveniently connected, allows displaying the variations of the voltage $U_R = U_{BC}$ as a function of time (Figure 2).

1- Derive the differential equation describing the variations of the current i in terms of R,L,E and t.



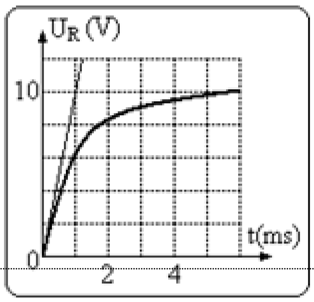


Figure 2

2- The solution of this equation is of the form: $i = A_1 - B_1 e^{\frac{-t}{\tau_1}}$. Determine the values of the constants A_1, B_1 and τ_1 and give the physical significance of each..

3- Referring to figure 2, verify that the values of τ_1 and A_1 are equal to those calculated above.

4- Determine:
   a) The duration t_1 at the end of which the steady state is practically reached.
   b) The value of the energy stored in the coil starting from t_1.

B- A disk in a rotational motion

A disk can rotate a horizontal axis (Δ) that is perpendicular to its plane through its center O. The moment of inertia I of the disk with respect to (Δ) is $I = 1.52 \times 10^{-5} kg.m^2$.

When subjected to a motive couple, of constant moment $\mathcal{M}_M = 9.12 \times 10^{-3} m.N$, the disk starts to rotate from rest at the instant $t_0 = 0$. At the instant t, the physical quantities θ and θ' are respectively the angular abscissa ant the angular velocity of the disk. During its rotation, the disk undergoes also a braking couple of moment $\mathcal{M}_F = -k\theta'$ where k is a positive constant of value $k = 3.04 \times 10^{-5}$ SI units.

Applying the theorem of angular momentum, show that the differential equation in θ' that describes the motion of the disk in written as: $I\frac{d\theta'}{dt} + k\theta' = \mathcal{M}_M$

C- An analogy

1- Match each of the physical electric quantities E, R, L, i, and $\frac{di}{dt}$ with the convenient mechanical physical quantity.

2- a) Determine the solution of the differential equation in θ'.
   b) Deduce the duration t_2 at the end of which the steady state is practically reached.
   c) Determine the angular velocity in the steady state.

GOOD WORK