Lebanese University
Faculty of Technology

الجامعة اللبنانيّة
كلية التكنولوجيا

September-15- 2021

Entrance Exam
(Engineering)
Physics Exam

Duration: 1H30

Exercise 1 (10 points)

Consider a small trolley (C) of mass m = 300 g, attached to one extremity of a horizontal spring (R); of negligible mass, and of un-jointed loops of stiffness k = 15 N/m; the other extremity of the spring is attached to a fixed support (A) (figure 1). The trolley (C) may slide without friction on a horizontal rail and its center of inertia G can move along the horizontal axis x'Ox.

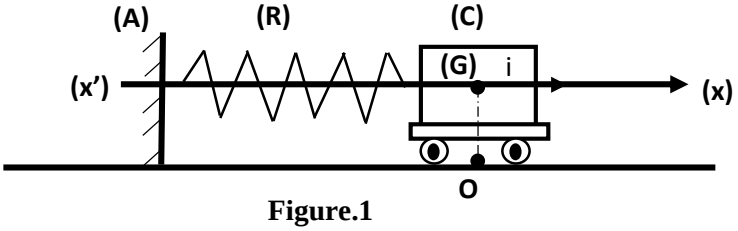

Figure.1

At the instant $t_0 = 0$, (G) is initially in its equilibrium position O, at this instant (C) is launched, at the instant $t_0 = 0$, with an initial velocity $\overrightarrow{V0} = -V_0\vec{i}$ ($V_0 > 0$). (C) then oscillates without friction with a proper angular frequency ω_0 .

At an instant t, the abscissa of G is x = $\overline{OG}$ and the algebraic measure of its velocity is $v = \frac{dx}{dt}$.

The horizontal plane passing through G is taken as a reference level of gravitational potential energy.

1) Write, at an instant t, the expression of the mechanical energy of the system [(C), (R), Earth] in terms of m, k, x and v.

2) Derive the second order differential equation in x that describes the motion of G.

3) The solution of this differential equation is of the form $x = -X_m \sin(\omega_0 t)$, where X_m is a positive constant.

a) Determine the expression of ω_0 in terms of k and m.

b) Deduce the value of the proper period T_0.

4) Determine the expression of the amplitude X_m in terms of V_0, k and m.

Exercise 2 (11 points)

Consider the circuit of figure 2. This circuit is formed of a function generator (LFG) delivering across its terminals an alternating sinusoidal voltage of frequency f, a coil of inductance L = 0.05 H and of negligible resistance, a resistor of resistance R = 10 KΩ and a capacitor of capacitance C.

The voltage across the LFG is $u_{AM} = U_m \sin \omega t$,($\omega = 2\pi f$) .The circuit thus carries an instantaneous current given by: $i = I_m \sin(\omega t + \varphi)$.

1) We denote by $u_C = u_{BN}$ the instantaneous voltage across the capacitor, by u_{AB} the voltage across the coil and by u_{NM} that across the resistor.

Show that:

a) $i = C \dfrac{du_C}{dt}$.

b) u_C may be written in the form: $u_C = -\dfrac{Im}{C\omega} \cos(\omega t + \varphi)$.

c) $u_{AB} = L\omega\, Im \cos(\omega t + \varphi)$.

2) The relation: $u_{AM} = u_{AB} + u_{BN} + u_{NM}$ is valid for any t . Show giving ω t a particular value, that:

$$\tan \varphi = \frac{\frac{1}{C\omega} - L\omega}{R}.$$

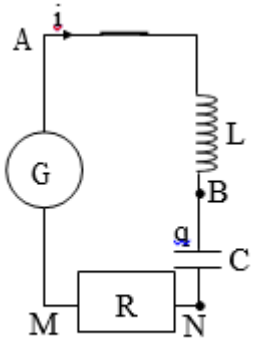

Figure 2

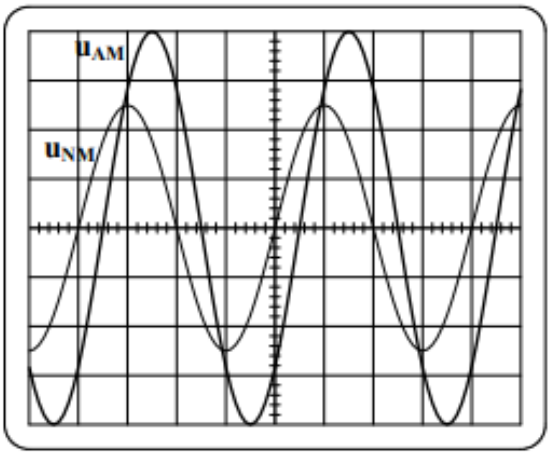

Figure 3

3) An oscilloscope, conveniently connected, displays the variations , as a function of time ,of u_{AM} and u_{NM} on the channels (Y_1) and (Y_2) respectively .These variations are represented in the waveforms of figure 3.

a) Redraw figure 2 showing the connections of the oscilloscope

b) The waveform of u_{NM} represents the « image » of the current i. Why?

c) Find the value of f, knowing that the horizontal sensitivity is 5ms/division.

d) Determine the phase difference φ between i and u_{AM}.

4) Deduce the value of the capacitance C.

5) The frequency f is made to vary, keeping the same effective value of u_{AM} . It is noticed that, for a value f_1 of f, u_{AM} is in phase with i.

a) Give the name of the phenomenon that appears in the circuit.

b) Deduce, from what preceded, the relation among L, C and f_1.

Exercise 3 **(9 points)**

A- A bar magnet may be displaced along the axis of a coil whose terminals A and C are connected to a resistor of resistance R.

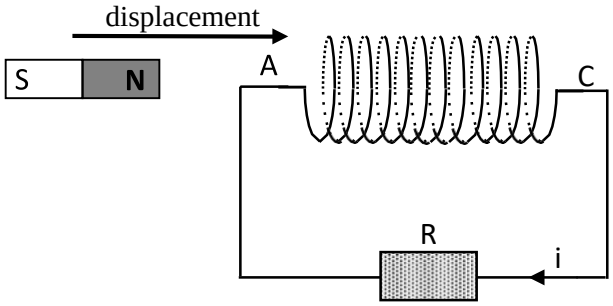

Figure 4

We approach the north pole of the magnet towards the face A of the coil (Fig.4). An induced current i is carried by the circuit.

1) Give the name of the physical phenomenon that is responsible for the passage of this current.

2) Give, with justification, the name of each face of the coil

3) The induced current passes from C to A through the resistor. Why?

4) Determine the sign of the voltage u_{AC}.

B- A coil of inductance L = 0.02 H and of negligible resistance is connected in series with a resistor of resistance R across a generator G (Fig.5). The coil thus carries a current i that varies with time as shown in figure 6.

1) Give the name of the physical phenomenon that takes place in the coil.

2) Determine the voltage u_{AC} in each of the two intervals: [0 ; 0.04s] and [0.04s ; 0.05s].

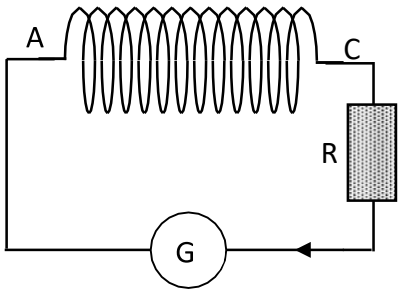

Figure 5

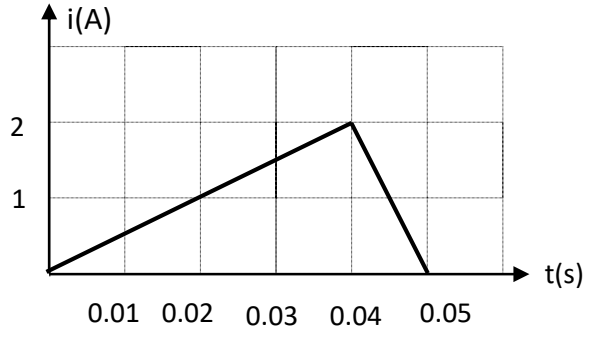

Figure 6