LEBANESE UNIVERSITY

University Institute of Technology

الجامعة اللبنانية

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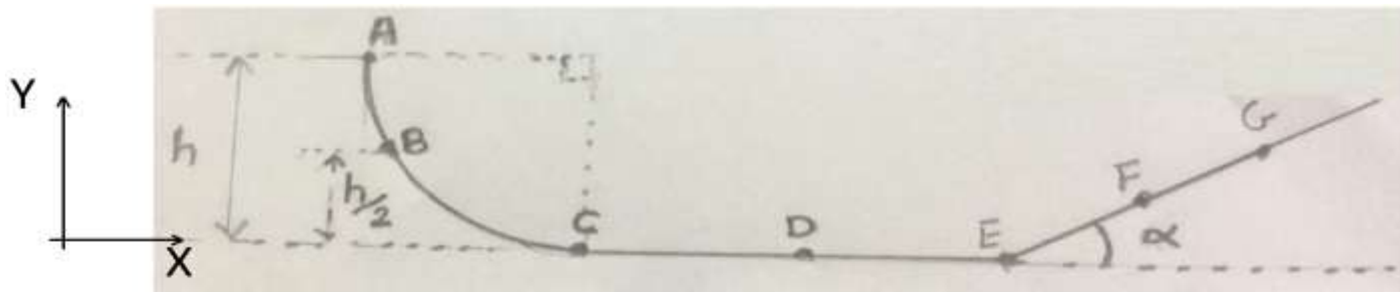
Entrance Exam: September 10, 2013

Physics **Duration: 2 H**

<u>Exercise I</u>: (12 points)

A metallic solid S, considered as punctual, is dropped, from a height h without initial velocity, on a frictionless track where the trajectory ABC is circular (1/4 of a circle) of radius R=h (figure below). After it passes point C, the solid S continues its movement with constant friction, first on the horizontal plan (trajectory CDE) then on the inclined plan at an angle $\propto$ before stopping at point G.

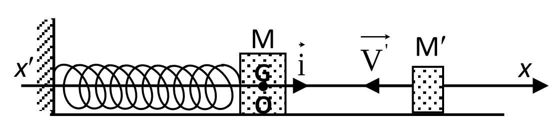


We give: the mass of the solid S is m= 0.1Kg; h= 5m; the velocity at the point E of S is V_E = 8m/s; $\propto$=30°; gravity g= 10m/s^2

The level of the horizontal plan (soil level) is considered as the level of reference of the potential energy.

1) Calculate the kinetic energy of the solid S at the moment of its crossing point B, where point B is at h_1= h/2. Deduce the values of the components V_{BX} (horizontal) and V_{BY} (vertical) of the velocity of S at point B.
2) Calculate the kinetic energy of the solid S at the moment of its crossing point D of the horizontal plan such as CD=CE/2.
3) Calculate the distance EG passed by S on the inclined plan.
4) Calculate the mechanical energy of the system (S, soil) when the solid S passes by the point F of the inclined plan such as EF=EG/2.

<u>Exercise II</u>: (12 points)



A spring of un-jointed loops, of stiffness constant k = 10 N/m and of horizontal axis, is fixed from one extremity to a fixed obstacle; the other extremity is attached to a puck M of mass m = 100 g. The center of inertia G of M can slide, without friction, along a horizontal axis x'x of origin O and unit vector $\vec{i}$. The horizontal plane passing through G is taken as a gravitational potential energy reference.

At the instant t_0 = 0, the puck M, initially at rest at O, is hit with another puck M' of mass m' = $\frac{m}{2}$ moving initially with a velocity $\overrightarrow{V'} = -V'\,\vec{i}$ (V′ > 0). After collision, the puck M' rebounds on M with a velocity $\overrightarrow{V'_1}$ and the puck M moves with a velocity $\overrightarrow{V_0} = V_0\,\vec{i}$, and performs oscillations with a constant amplitude X_m = 10 cm.

1) Give the sign of V_0.
2) Let x and v be respectively the algebraic values of the abscissa and the velocity of G at an instant t after the collision.
   a) Write, in terms of x, m, k and v, the expression of the mechanical energy of the system (M, spring, Earth) at the instant t.
   b) Derive the differential equation of second order in x that describes the motion of M.
   c) The solution of this differential equation is of the form $x = A\sin(\omega_0 t + \varphi)$. Determine the values of the positive constants A, ω_0 and φ.
   d) Deduce that the magnitude of the velocity $\overrightarrow{V_0}$ of M just after the collision is 1 m/s.
3) Knowing that the collision between M' and M is supposed to be perfectly elastic, determine:
   a) the value V' of the velocity of M' before collision;
   b) the velocity $\overrightarrow{V_1'}$ of M' just after the collision.

Exercise III: (10 points)

The circuit of figure 1 is formed of a function generator (LFG) delivering across its terminals an alternating sinusoidal voltage of frequency f, a coil of inductance L = 0.07 H and of negligible resistance, a resistor of resistance R = 100 KΩ and a capacitor of capacitance C. The voltage across the LFG is $u_{AM} = U_m \sin \omega t$ .The circuit thus carries an instantaneous current given by: $i = I_m \sin(\omega t+\varphi)$

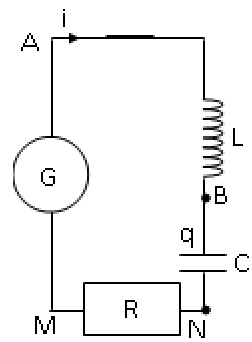


Figure 1

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: $u_C = \dfrac{-I_m}{C\omega}\cos(\omega t + \varphi)$.

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

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

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

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 2.

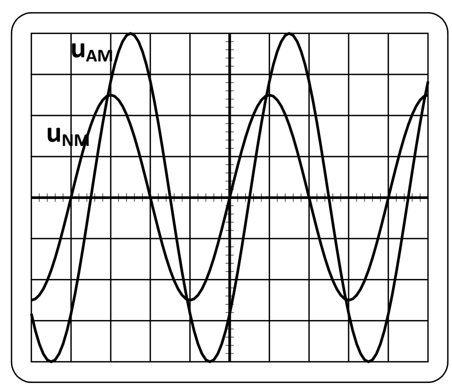


Figure 2

a) Redraw figure 1 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 the frequency 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.

<u>Exercise VI</u>: (6 points)

1) The Figure 1 represents the diagram of a loaded transformer. The generator delivers an alternating sinusoidal voltage of frequency f .The coil (1) carries an alternating sinusoidal current i_1 of frequency f. The coil (2) thus carries an alternating sinusoidal current i_2 having the same frequency f. Explain the existence of the current in coil (2).

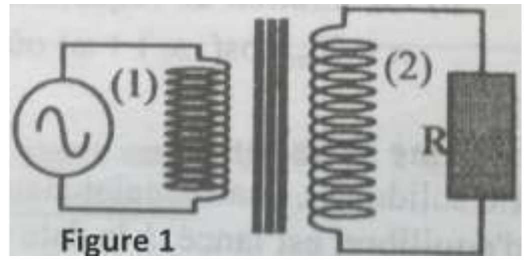


Figure 1

2) The object of this part is to show evidence of the role of a transformer in the transmission of electric energy. An electric generator G delivers a power P = 20 kW under an alternating sinusoidal voltage of effective value U. A transmission line of total resistance r = 1Ω feeds an electric installation (B). Let I be the effective current that passes in the line. The power factor of the system formed of the line and the installation is cosφ = 0.95 .

a) Give the expression of the power P in terms of U, I and cosφ.

b) i) Give the expression of the power P' lost in the line due to Joule's effect in terms of P, r, cosφ and U.

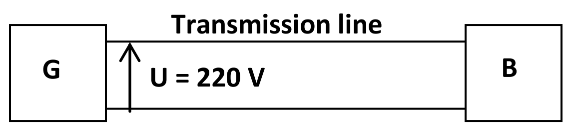


Figure 2

ii) Calculate P' in the case when U = 220 V (Figure 2)

iii) A transformer, connected across the generator, raises the effective value of the voltage across the transmission line . The transmission of the same power P through the line thus takes place under the new effective voltage U = 10^4 V (Figure 3).

Calculate the new value of P'.

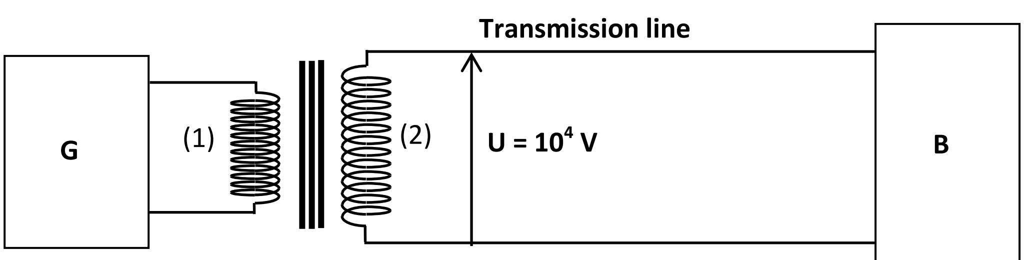


Figure 3

c) Draw a conclusion about the importance of the usage of the transformer in the transmission of electric energy over large distances.