LEBANESE UNIVERSITY
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الجامعة اللبنانية
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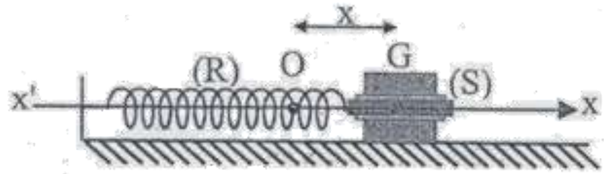
Entrance Exam: 10 September 2014

Physics: CE - CCNE **Duration: 2 hours**

All questions are obligatory

Exercise I (10 points)

An elastic pendulum is formed of a spring (R) of unjoint turns on a horizontal $x'Ox$ axis, of negligible mass and constant K, and a solid (S) of mass m. The spring takes its initial length when the center of inertia of (S) is at point O. The pendulum oscillates without friction on $x'Ox$ axis.



At a given instant, the center of inertia G of (S) is referred to by the abscissa $x = \overline{OG}$.

The zero level of the gravitational potential energy is the horizontal plane passing through $x'Ox$.

1) Determine, as a function of x, m, K and the speed V of (S), the mechanical energy of the system (pendulum, Earth).

2) Using the conservation of mechanical energy, write the differential equation of the motion of (S). What is the nature of this motion?

3) Find the preceding differential equation, again, by applying Newton's second law.

4) Determine the expressions of proper angular frequency and the proper period of oscillation of (S).

5) Verify that the solution of the preceding differential equation is under the form:

$x = x_m \cos(\omega_0 t + \varphi)$ where x_m and φ are constants.

6) Determine the expressions of the speed and the acceleration of (S). What is the particular orientation of the acceleration?

Exercise II (4 points)

The emission spectrum of the ionized lithium atom Li^{2+} shows the existence of a ray of wavelength $\lambda_{54} = 450{,}91$ nm.

Knowing that the values of the energy levels of the ion Li^{2+} are under the form $E_n = \dfrac{A}{n^2}$, where A is a constant and n is a none zero integer. E_n is expressed in electronvolt.

1) What are the unit and the sign of A?

2) Verify that the wavelength emitted by the atom during its transition between E_p and E_n is given by:

$\dfrac{1}{\lambda_{pn}} = \dfrac{A}{hc}\left(\dfrac{1}{p^2} - \dfrac{1}{n^2}\right)$ where $p > n$.

3) Deduce the value of A.

4) Calculate the minimum energy necessary to ionize the ion Li^{2+}.

Given: Plank constant h = $6{,}63.10^{-34}$ J.s and light velocity in air c = 3.10^{8} m/s.

Exercise III (16 points)

We consider a coil of inductance L and of resistance r, a capacitor of capacitance C and a variable resistor R, an LFG delivers an alternating sinusoidal voltage of constant effective value U and of frequency f such that: $u = U\sqrt{2}\cos(2\pi f.t)$, where u in volt and t in second.

Let u_R be the voltage across R. We use the preceding dipoles to connect the circuit as in figure 1. We connect the oscilloscope to the circuit to observe u and u_R.

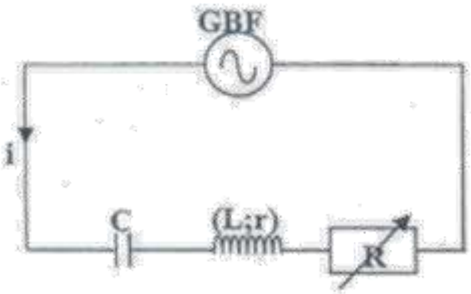
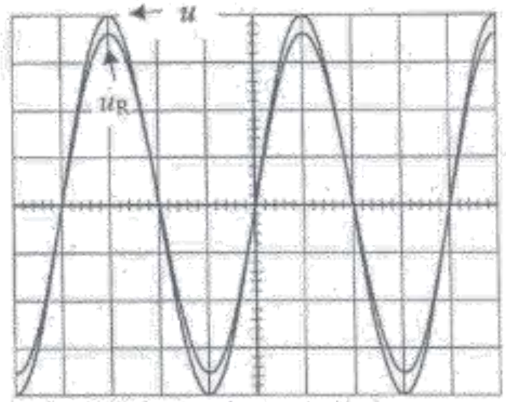


Figure (1)

Figure (2)



Given:

The vertical sensitivity of the two channels: $S_v = 1$ V/div.

The horizontal sensitivity: $S_h = 2$ ms/div.

A) Studying the electromagnetic phenomenon

We give R the value $R_1 = 100\ \Omega$

1) We vary the frequency f of the LFG and we fix it to a value f_0, we obtain on the oscilloscope the figure 2.

a) What is, with justification, the name of the phenomenon taking place?

b) Calculate: U, f_0, the effective intensity I_0 of the current and the value of r.

c) Represent graphically $I = f(f)$: the effective current I as a function of the frequency f and precise on this curve the point of coordinates $(I_0\,;\, f_0)$.

2) We give R the value $R_2 = 200\ \Omega$. The frequency of the LFG is f_0.

a) If it is possible, study the variation of the amplitudes, of the period and of the phase difference of the oscillograms in figure 2.

b) Represent, with justification, the new curve of $I = f(f)$ in preceding system?

B) Calculating the values of *L* and *C*

The value of R is $R_1 = 100\ \Omega$. We regulate the LFG to a frequency $f = 50$ Hz, the phase difference between the voltages u and u_R becomes $\varphi = 0.47$ rad.

1) Is the phase difference of the current i with respect to u positive or negative? Why?

2) Applying the "addition law" of the voltages and giving t the values $t_1 = \frac{1}{4f}$, $t_2 = -\frac{\varphi}{2\pi f}$ and using the preceding part A).

a) Verify the expression: $\tan\varphi = \dfrac{1-\left(\frac{f}{f_0}\right)^2}{2\,\pi\, f\, C\,(R+r)}$.

b) Calculate C, L and the effective current value I.

Exercise IV (4 points)

A ping-pong ball of mass m = 2.7 g and of radius R = 2 cm, is released vertically, in air without initial speed, from a point O of height H = 24 m from the ground. The ball moves on a rectilinear pat hand reaches a limiting speed V_ℓ = 9 m /s after covering 10 m.

The ball is subjected to air resistance represented by a forces $\vec{f}$ opposite to its displacement and of a value f proportional to the speed V such that: $f = 6\,\pi\eta R V$ (η is a positive constant called the coefficient of viscosity of air). Given gravitational acceleration g = 9.8 m/s^2.

1) Applying Newton's second law $\sum \vec{F} = m\frac{d\vec{V}}{dt}$ on the ball:

a) Calculate $\frac{dV}{dt}$ as a function of m, g, η, R and V.

b) The limiting speed of the ball is reached when its motion becomes uniform. Determine the expression of the limiting speed as a function of m, g, η, and R.

c) Deduce the value of η and give its unit.

2) What is the speed of the ball when it reaches the ground?

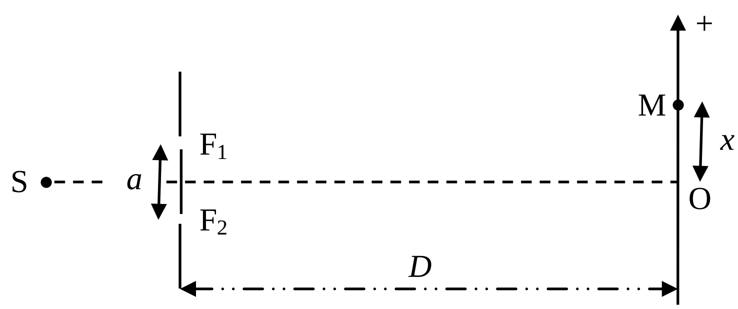
Exercise V (6 points)

A source S illuminates two fine rectangular slits F_1 and F_2, that are fine and a distance a = 1 mm. The source S is found on the perpendicular to the plane of the slits, at an equal distance from each slit. A screen is placed at a distance D = 2 m from the plane of the slits.

The perpendicular from S to the plane of the slits cuts the screen at point O.

A point M on the screen is referred by $x = \overline{OM}$.

The source S emits a light of λ = 589 nm. Interference fringes appear on the screen.



1) Define the interfringe distance and calculate its value.

2) Determine, as a function of a, x, λ, D and k, the abscissas of the centers of dark and bright fringes of order k.

3) The source S emits two monochromatic radiations of wavelength λ = 589 nm and λ′ (unknown). We notice that the bright fringe of order 7 of the radiation λ coincides with the 8th dark fringe of the radiation λ′. Calculate λ′.

4) The source S emits white light. We place the slit of a spectroscope at a point of abscissa x = 5 mm.

a) What is the color of the fringe at O? Justify

b) The spectroscope shows thin spectra formed of black bands. What is the formation of these bands due to?

c) Calculate the wavelengths of the bands in the visible spectrum (400 nm ≤ $\lambda_{visible}$ ≤ 750 nm).