I-(7 points)
Determination of a characteristic of a coil

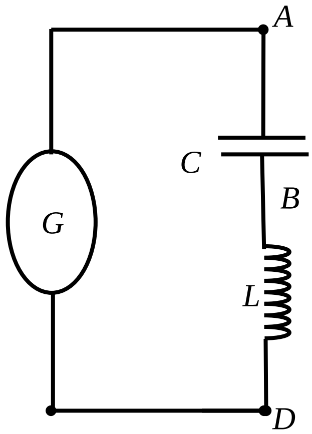

Figure 1

In order to determine the resistance r of a coil of inductance $L = 0.032\ H$, we connect it in series with a capacitor of capacitance $C = 160\ \mu F$ across the terminals of a low frequency generator (LFG) delivering an alternating sinusoidal voltage. Take: $0.32\ \pi = 1$.

The circuit thus carries an alternating sinusoidal current i.

An oscilloscope is connected so as to display the voltage u_g on the channel Y_1, and the voltage across the coil u_L on the channel Y_2.

We see on the screen of the oscilloscope a display of the waveforms represented in figure 2.

Let $S_{v_1} = 2.5 V/div$ be the vertical sensitivity on channel Y_1.

and S_{v_2} be the vertical sensitivity on channel Y_2.

The voltage across the coil is given by: $u_L = 10\sin(100\pi t)$

(u in V & t in s).

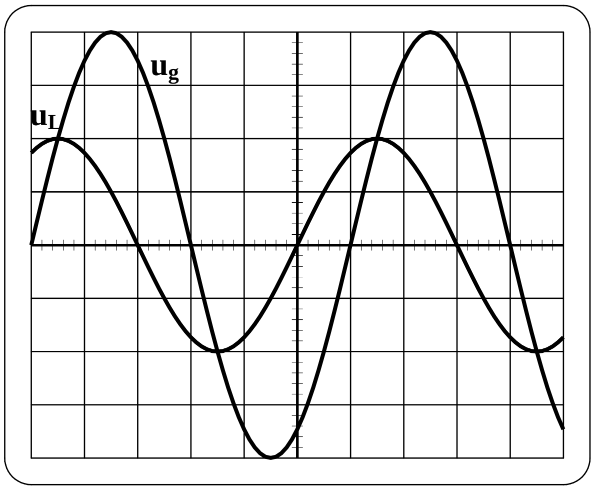

Figure 2

1.Redraw figure (1) showing on it the connections of the oscilloscope.

2.a)Find the vertical sensitivity S_{v_2} on channel Y_2.

b)Find the frequency of signal delivered by the LFG.

3.a)Calculate the phase difference between u_G and u_L.

Which of them leads the other.

b)Deduce the expression of the voltage u_{AD} across the terminals of the generator as a function of time.

4.By supposing that $u_C = u_{AB} = U_m \sin(100\pi t + \phi)$.

Applying the law of addition of voltages, and giving the time two particular values. Find the values of U_m and ϕ.

5.a)Deduce that the instantaneous expression of the current i as a function of time is given by: $i = 0.5\sin\left(100\pi t - \frac{\pi}{6}\right)$.

b)Using two expressions of the average power consumed across the coil, the expression justified in part 5 and that of u_L, for $w = 100\pi\ rad/s$.

Find the value of r.

6.We keep the maximum value of u_g constant but we vary its frequency f; the effective value of the current in the circuit is maximum for certain value f_0.

a)What is the name of the physical phenomenon thus observed?

b)Find the value of f_0.

c)The circuit is now equipped by a fuse that cannot withstand a current whose effective intensity exceed $400\ mA$.

Show that it is not possible to visualize the preceding physical phenomenon.

II-(6 points)

Photons and vision

According to Planck-Einstein's Hypothesis:

«An electromagnetic radiation of frequency υ, is composed of energy particles called photons».

Given:

- $1nm = 10^{-9} m$.
- $1eV = 1.6 \times 10^{-19} J$.
- The speed of light in vacuum $c = 3 \times 10^{8} m/s$

1.a)What aspect of light, the previous statement , does it show evidence of?

b)State two physical properties of the photon.

c)What is meant by duality of light? Give a physical phenomenon that is interpreted basing on each aspect.

2.To study the relationship between the energy E of a photon and its frequency υ, we measure the photon's energy of many electromagnetic radiations that are placed in the following table.

$\upsilon(\times 10^{14})Hz$	0.3	3.75	5	7.5	15
$E(eV)$	0.124	1.56	2.1	3.11	6.21

a)Plot the graph representing the variations of the energy of a photon as a function of the frequency υ, by taking as a scale:

On the abscissas axis: $1cm \equiv 1 \times 10^{14} Hz$.

On the ordinate axis : $1cm \equiv 0.5\ eV$

b)Justify, basing on the graph plotted and by the means of two evidences , that the energy of a photon is proportional to the frequency υ.

c)Determine, in SI units , the value of this constant of proportionality , called Planck's constant h.

d)Knowing that the spectrum of visible light in vacuum extends in the interval : $400 nm \leq \lambda \leq 750 nm$.

*i)*Find the range of frequencies of visible light.

*ii)*Indicate to which domain the radiations mentioned in the previous table belong , the visible, ultraviolet or infrared spectrum?

In what follows we consider that the Planck's constant h is equal to: $h = 6.64 \times 10^{-34} J$.

3.To start up a visual excitation, 100 photons at least must reach the retina whose area is $0.15 \times 10^{-9} m^2$ during a duration of $0.1 s$. The retina's surface holds 20 rods.

a)What is the number of photons needed to provoke an excitation of a rod during this duration.

b)***i)***Write the expression of a photon's energy in terms of $h, c \& \lambda_0$.

ii)What is the power absorbed by a rod receiving a radiation whose wavelength is $\lambda_0 = 550 nm$.

c)What must be the minimum power of a luminous source emitting this same radiation uniformly in all directions of the space in order to be visible from $10 km$.

III- (7 points)
Horizontal elastic pendulum and Earthquakes

Part A
Theoretical study

The horizontal elastic pendulum of the figure below is formed of a solid (S) of mass $m = 100g$ and a spring of constant $k = 10N/m$. The center of mass G of (S) may move along a horizontal axis $\left(O, \vec{i}\right)$ as shown in Figure1. The abscissa of G at any instant t during oscillations is x and its velocity is $\vec{v} = v\,\vec{i}$.
The horizontal plane containing G is taken as the gravitational potential energy reference.
The pendulum thus performs free undamped oscillations of amplitude $x_m = 4cm$.

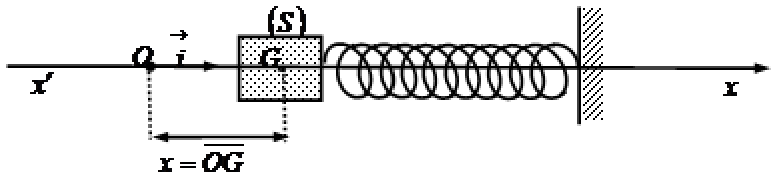

Figure 1

1. Write the expression of the mechanical energy ME of the pendulum [(S), spring] as a function of m, k, x and v.
2. Derive the differential equation that describes the motion of the center of mass G .
3. a) Determine the expression of T_0 so that $x = x_m \cos\left(\frac{2\pi}{T_0}t\right)$ is the solution of this differential equation.

   b) Deduce the value of the proper period T_0.
4. Applying the principle of conservation of mechanical energy, find the speed of the box when it passes through the equilibrium position.

Part B
Functioning of a seismometer

A seismometer is a device used to detect and record any disturbance of Earth. It functions on the principle of a damped oscillator solid-spring connected to a building fixed to ground. The seismometers are sensitive to vertical and horizontal vibrations. We are interested to the functioning of a horizontal seismometer.

In fact a seismic signal can hold waves, that are produced at a point called epicenter, of which we study in particular two types P and S, having periods that extends from few hundredths of second to many minutes and the recording obtained is shown in Figure 2. The seismometer enters in resonance for a particular frequency. It acts equally as a damping system, necessarily to obtain a reliable restitution of the ground motion.

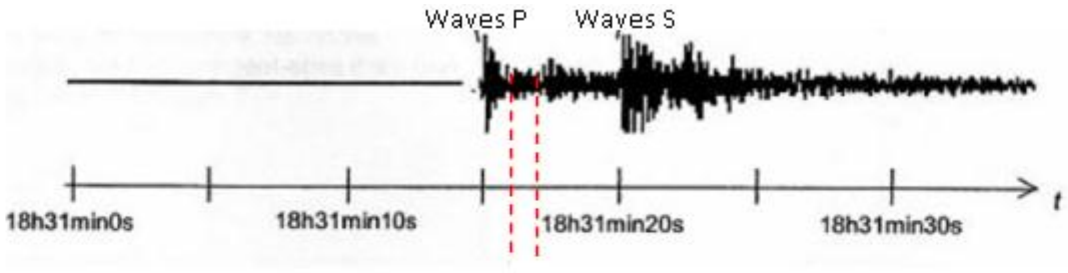

Figure 2

1. Indicate in this system: the exciter? The resonator?
2. By admitting that the damping is weak; for what period of the exciter, the resonance phenomenon takes place?
   Note: without the phenomenon of resonance, the relative motion is very weak and the recording is not reliable.
3. To simplify the study we consider that the waves P and S are periodic as indicated in figure2.
   a) Which wave propagates faster P or S basing on the previous recording? Justify.
   b) Observing the recording, specify the range of magnitude of the periods T , shown in the previous recording, of waves P and S is $10s$, $1s$ or $0.1s$ from figure2 above.
   c) Calculate an approximate value of the solid mass m , during this Earthquake.
   The constant of spring $k = 100 N.m^{-1}$.
4. During the seism, certain waves have frequencies very small to that of the waves P and S . How should we modify the mass m in order to obtain a reliable recording?

IV-
Variations of the period

The objective of this study is to find the parameters that effect on the duration of oscillation of a mechanical oscillator (elastic pendulum) whose oscillation takes an interval of time T .

A-Experimental study

In order to show the effects of the oscillations amplitude x_m , the mass m of the solid and the constant k of the spring on the duration of one oscillation of a free undamped horizontal elastic pendulum.
We perform many experiments, in each one factor is only modified x_m in the first, k in the second and k in the third then we measure each time, the duration Δt for 10 oscillations using a stopwatch.
1.Why we measure the duration of 10 oscillations instead of 1 only directly?
2.The curves below are obtained:
What is, with justification, the conclusion that can be drawn concerning the dependence of the proper period T on:

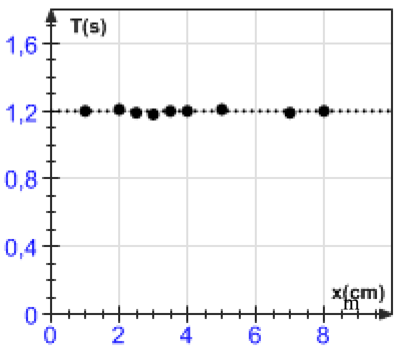

Figure 1

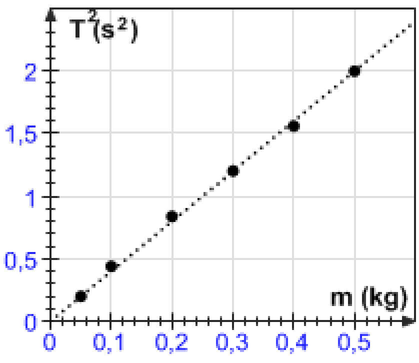

Figure 2

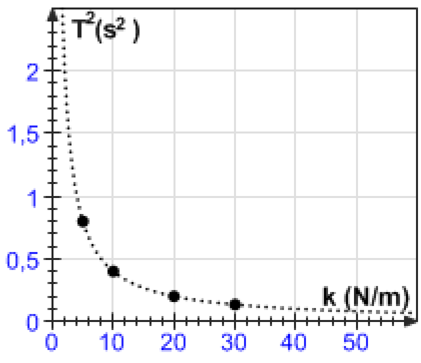

Figure 3

a)the amplitude x_m from figure 1?
b)the mass m from figure 2? Deduce the expression of T in terms of $\sqrt{m}$.
c)the constant of elasticity k from figure 3?

3.By supposing that the proper period can be written in the form $T = A x_m^{\alpha} m^{\beta} k^{\gamma}$ where $A, \alpha, \beta \& \gamma$ are constants.
a)What must be the value of the constant α so that the expression of the period T is independent of the amplitude x_m ?

b)Verify that the unit of the constant of elasticity k in SI units is $kg.s^{-2}$.

c)Basing on dimensional study (units study) applied on the expression of the proper period. Show that the value of $\gamma = -\frac{1}{2}$ .Deduce the value of β ?

d)Knowing that the values of figure 2 are obtained when the constant of the spring $k = 10 N/m$. Deduce the value of the constant A.

B-Theoretical study

Consider a horizontal elastic pendulum formed of a solid (S) of mass m attached to a spring of constant k and of negligible mass; the other end of the spring is fixed to a support. The forces of friction are supposed to be negligible and the solid of center of mass G can move on a horizontal axis Ox.

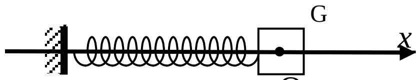

Fig.1

When the solid is at rest, G coincides with the point O taken as origin of abscissa.

The solid is pulled from its equilibrium position by a distance x_m, and then released without initial velocity at the instant $t_0 = 0$. The horizontal plane passing through G is taken as a gravitational potential energy reference. At any instant t, the abscissa of G is x and the algebraic measure of its velocity is $v = \frac{dx}{dt}$.

1.Write down the expressions of the mechanical energy of the system (Solid, spring, Earth) as a function of m, k, x and v.

2.a)Derive the second order differential equation that governs the motion of (S).

b)Knowing that $x = x_m \cos\left(\frac{2\pi}{T}t + \phi\right)$ is a solution of this differential equation , determine the expression of the natural period T as a function of m and k.

c)Compare this result to that obtained in A.3-d