

الدورة الإستثنائية للعام 2009	امتحانات الشهادة الثانوية العامة الفرع : علوم الحياة	وزارة التربية والتعليم العالي المديرية العامة للتربية دائرة الامتحانات
الاسم: الرقم:	مسابقة في مادة الفيزياء المدة ساعتان	

This exam is formed of three exercises in three pages.
The use of non-programmable calculators is recommended.

First Exercise (7 points)

Response of an (r, L, C) circuit to an alternating sinusoidal voltage

Consider the series circuit that is represented in figure 1. This circuit is formed of a coil of inductance L and of resistance r, a capacitor of adjustable capacitance C , and a generator G delivering across its terminals an alternating sinusoidal voltage :

$$u_g = u_{AB} = 10\sqrt{3} \sin\left(\frac{200\pi}{3}t + \phi\right), \quad (u_g \text{ in V, } t \text{ in s}).$$

For a certain value of the capacitance C, the circuit carries an alternating sinusoidal current $i = \sin\left(\frac{200\pi}{3}t\right)$, (i in A, t in s). (Take $0.32\pi = 1$).

An oscilloscope, connected as shown in figure 1, displays the voltage u_{AM} across the coil on channel Y_A , and the voltage $u_{MB} = u_C$ across the capacitor on channel Y_B , the « INV » button of channel Y_B being pressed.

On the screen of the oscilloscope, we observe the waveforms represented in figure 2.

The vertical sensitivity on both channels is $S_V = 5 \text{ V/div}$.

- 1) Referring to figure 2 :
 - a) Determine the horizontal sensitivity of the oscilloscope;
 - b) Determine the amplitudes U_{AMmax} and U_{Cmax} of the voltages u_{AM} and u_C ;
 - c) Show that the phase difference ϕ' between the voltages u_{AM} and u_C is $\frac{2\pi}{3}$ rad. Specify the voltage that leads the other.

- 2) a) i) Write down the relation among i , C and $\frac{du_C}{dt}$.
- ii) Show that the voltage u_C across the terminals of the capacitor is given by : $u_C = \frac{3}{200\pi C} \sin\left(\frac{200\pi}{3}t - \frac{\pi}{2}\right)$.

- iii) Deduce that the value of C is 240 μF .

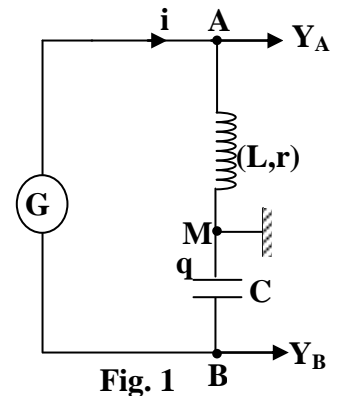


Fig. 1

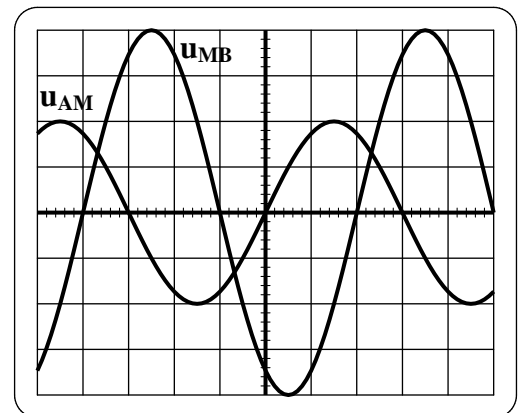


Fig.2

b) i) Using figure 2 and the expression of u_C , determine the expression of u_{AM} as a function of time.

ii) Give the expression of u_{AM} in terms of r , i , L and $\frac{di}{dt}$.

iii) Using the preceding results, and by giving t two particular values, show that

$$r = 5\sqrt{3} \Omega \text{ and } L = 0.024 \text{ H.}$$

3) The relation $u_g = u_{AM} + u_{MB}$ is valid for any time t . Determine ϕ knowing that $-\frac{\pi}{2} < \phi_{\text{rad}} < \frac{\pi}{2}$.

4) The value of C is made to vary. We notice that, for a certain value C' of C , the amplitude of i attains a maximum value.

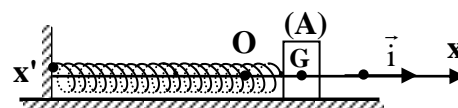
a) Give the name of the physical phenomenon that thus took place.

b) Determine C' .

Second Exercise (7 points)

Mechanical Oscillations

The aim of this exercise is to study different modes of oscillations of a horizontal elastic pendulum that is formed of a puck (A), of mass $m = 200 \text{ g}$, and a spring of un-jointed turns of negligible mass and of stiffness $k = 80 \text{ N/m}$.



The position of the center of mass G of (A) is defined, at an instant t , on an axis $\mathbf{x}'\mathbf{x}$, by its abscissa $x = \overline{OG}$;

the velocity of G is then $\vec{V} = V\vec{i}$ where $V = x' = \frac{dx}{dt}$.

The horizontal plane containing G is taken as a gravitational potential energy reference.

A – Free un-damped oscillations

At the instant $t_0 = 0$, the center of mass G of (A) being at O (origin of abscissa), (A) is launched with a velocity $\vec{V}_0 = V_0\vec{i}$ ($V_0 = 2.5 \text{ m/s}$). (A) thus moves along the support without friction.

1) Calculate the mechanical energy of the system [(A), spring, Earth].

2) a) Give, at the instant t , the expression of the mechanical energy of the system [(A), spring, Earth] in terms of x , k , m , and V .

b) Determine the differential equation that describes the motion of G .

c) Determine the value of the proper angular frequency ω_0 and that of the proper period T_0 of the oscillations.

3) The solution of the obtained differential equation has the form: $x = X_m \cos(\omega_0 t + \varphi)$.

Determine the values of the constants X_m and φ .

B – Free damped oscillations – Driving the oscillations

Now, G is at rest at O . We shift (A) by 12.5 cm from O and then we release it from rest at the instant $t_0 = 0$. (A) thus performs pseudo-periodic oscillations of pseudo-period T . At the end of 10 oscillations, the amplitude of the motion becomes 12 cm .

1) Calculate the variation in the mechanical energy of the system during these 10 oscillations.

2) The value of T is very close to that of T_0 . Why?

3) In order to drive the oscillations of (A), a convenient apparatus provides the oscillator with an energy E during these 10 oscillations.

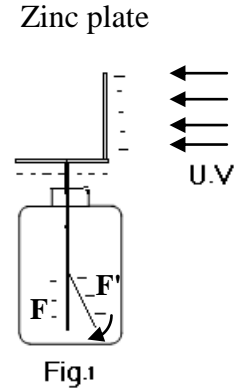
a) What does the term « driving the oscillations » mean?

b) Calculate the average power P_{av} furnished during these 10 oscillations.

Third Exercise (6 points) Photoelectric Effect

Given : speed of light in vacuum $c = 3 \times 10^8$ m/s ; $1 \text{ eV} = 1.6 \times 10^{-19}$ J.

A) The photoelectric effect was discovered by Hertz on 1887. The experiment represented in figure 1 may show evidence of this effect. A zinc plate is fixed on the conducting rod of an electroscope. The whole set-up is charged negatively. If we illuminate the plate by a lamp emitting white light rich with ultraviolet radiations (U.V), the leaves F and F' of the electroscope approach each other rapidly.



- 1) Due to what is the approaching of the leaves?
- 2) The photoelectric effect shows evidence of an aspect of light.
What is this aspect?

B) The experiments performed by Millikan towards 1915, intended to determine the maximum kinetic energy K.E of the electrons emitted by metallic plates when illuminated by monochromatic radiation of adjustable wavelength λ in vacuum.

In an experiment using a plate of cesium, a convenient apparatus allows us to measure the maximum kinetic energy K.E of an emitted electron corresponding to the wavelength λ of the incident radiation.

The variation of K.E as a function of λ is represented in the graph of figure 2.

The aim of this part is to determine the value of Planck's constant h and that of the extraction energy W_0 of cesium.

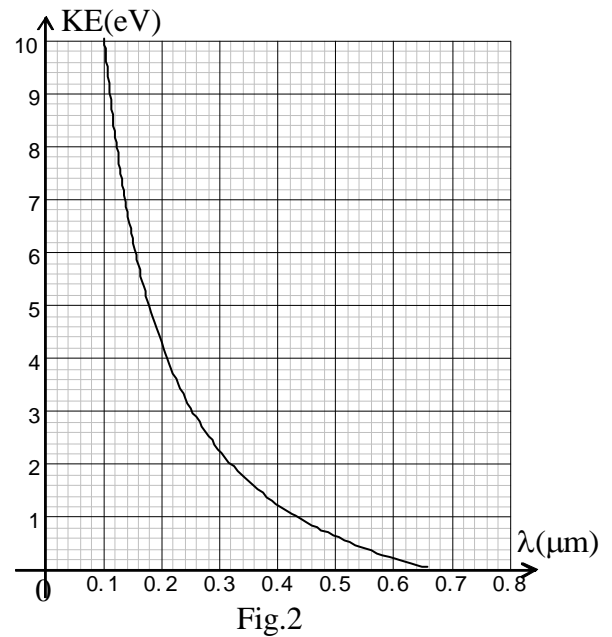
- 1) Write down the expression of the energy E of an incident photon, of wavelength λ in vacuum, in terms of λ , h and c .
- 2) a) Applying Einstein's relation about photoelectric effect, show that the maximum kinetic energy K.E of an extracted electron may be written in the form

$$K.E = \frac{a}{\lambda} + b, \text{ where } a \text{ and } b \text{ are constants.}$$

b) Deduce the expression of the threshold wavelength λ_0 of cesium in terms of W_0 , h and c .

3) Referring to the graph:

- a) Give the value of the threshold wavelength λ_0 of cesium;
- b) Determine the value of W_0 and that of h .



First Exercise (7 points)

1) a) The angular frequency is $\omega = \frac{200\pi}{3} = \frac{2\pi}{T} \Rightarrow$ The period is $T = 30$ ms

The period extends over 6 divisions $\Rightarrow S_h = \frac{30}{6} = 5$ ms/div. (3/4)

b) $U_{bmax} = 2\text{div} \times 5V/\text{div} = 10$ V ; $U_{Cmax} = 4\text{div} \times 5V/\text{div} = 20$ V. (1/2)

c) ϕ' corresponds to 2 div. $\Rightarrow \phi' = \frac{2\pi \times 2}{6} = \frac{2\pi}{3}$ rad. u_b leads u_c by ϕ' (3/4)

2) a) i) $i = C \frac{du_C}{dt}$. (1/4)

ii) $i = C \frac{du_C}{dt} \Rightarrow u_C = \frac{1}{C} \text{pri. of } i = -\frac{1}{C} \frac{3}{200\pi} \cos(\frac{200\pi}{3}t)$

$\Rightarrow u_c = \frac{3}{200\pi C} \sin(\frac{200\pi}{3}t - \frac{\pi}{2})$. (1/2)

iii) $\frac{1}{C} \frac{3}{200\pi} = U_{Cmax} = 20$ V $\Rightarrow C = 2.4 \times 10^{-4}$ F. (1/2)

b) i) $u_b = 10 \sin(\frac{200\pi}{3}t - \frac{\pi}{2} + \frac{2\pi}{3}) = 10 \sin(\frac{200\pi}{3}t + \frac{\pi}{6})$. (1/2)

ii) $u_b = ri + L \frac{di}{dt}$ (1/2)

iii) $u_b = ri + L \frac{di}{dt} = 10 \sin(\frac{200\pi}{3}t + \frac{\pi}{6}) = r \sin(\frac{200\pi}{3}t) + \frac{200\pi}{3} L \cos(\frac{200\pi}{3}t)$.

For $t = 0$, we get : $5 = 0 + \frac{200\pi}{3}L \Rightarrow L = 24$ mH.

For $\frac{200\pi}{3}t = \frac{\pi}{2}$, we get : $10 \times \frac{\sqrt{3}}{2} = r + 0 \Rightarrow r = 5\sqrt{3} = 8.66$ Ω . (1)

3) $u_g = u_b + u_c \Rightarrow 10\sqrt{3} \sin(\frac{200\pi}{3}t + \phi) = 10 \sin(\frac{200\pi}{3}t + \frac{\pi}{6}) + 20 \sin(\frac{200\pi}{3}t - \frac{\pi}{2})$.

For $t = 0$, we get : $10\sqrt{3} \sin \phi = 5 - 20 = -15 \Rightarrow \sin \phi = -\frac{\sqrt{3}}{2} \Rightarrow \phi = -\frac{\pi}{3}$ rad (3/4)

4) a) Current resonance (1/4)

b) At resonance, $LC'\omega^2 = 1 \Rightarrow C' = \frac{1 \times (3)^2}{0.024 \times (200\pi)^2} = 9.6 \times 10^{-4}$ F. (3/4)

Second Exercise (7 points)

A -

1) M.E = K.E + P.E_c + P.E_g ; P.E_c = 0 , Since (A) is at O and P.E_g = 0 (reference)

Thus M.E = K.E = $\frac{1}{2} m V_0^2 = \frac{1}{2} (0.2)(2.5)^2 = 0.625$ J (1)

2) a) M.E = K.E + P.E_c = $\frac{1}{2} m V^2 + \frac{1}{2} k X^2$ (1/2)

b) No friction \Rightarrow M.E is conserved $\Rightarrow \frac{dM.E}{dt} = 0 \Rightarrow$

$\frac{1}{2} (m)(2)(V)\dot{x} + \frac{1}{2} k(2)(V) = 0 \Rightarrow \ddot{x} + \frac{k}{m} x = 0$ (1/2)

c) $\omega_0 = \sqrt{\frac{k}{m}} = 20$ rd/s and $T_0 = 2\pi \sqrt{\frac{m}{k}} = 0.314$ s (1)

3) At max. elongation K.E = 0 Thus M.E = $\frac{1}{2} k X_m^2$
The conservation of M.E gives : $0.625 = \frac{1}{2} (80) X_m^2 \Rightarrow X_m = 0.125$ m
 $x = X_m \cos(\omega_0 t + \phi)$ and $V = -X_m \omega_0 \sin(\omega_0 t + \phi)$

For $t = 0$; $x = 0 \Rightarrow \cos \phi = 0 \Rightarrow \phi_1 = \frac{\pi}{2}$ and $\phi_2 = -\frac{\pi}{2}$

For $t = 0$; $V = 2.5$ m/s $\Rightarrow 2.5 = -0.125 \times 20 \sin \phi \Rightarrow \sin \phi = -1$

$\Rightarrow \phi = -\frac{\pi}{2}$ rd (1/2)

B -

1) $\Delta M.E = \frac{1}{2} k (X_{2m}^2 - X_{1m}^2) = -0.049$ J (3/4)

2) Frictional forces are too small. (1/4)

3) a) To provide the oscillator with the necessary energy needed to compensate for the losses and maintain its amplitude constant. (1/2)

b) The work supplied by the apparatus is : $E = |\Delta M.E|$

$\Rightarrow P_{Av} = \frac{0.049}{10 \times 0.314} = 0.016$ w. (1)

Third Exercise (6 points)

A –

- 1) The plate has excess of electrons; when the plate is exposed to U.V radiations, electrons are extracted, which explains the discharge of the electroscope. **(3/4)**
- 2) Corpuscular aspect **(1/2)**

B – 1) $E = \frac{hc}{\lambda}$ **(1/4)**

2) a) $E = K.E + W_0 \Rightarrow K.E = \frac{hc}{\lambda} - W_0 = \frac{a}{\lambda} + b$ with $a = hc$ and $b = -W_0$. **(1 1/4)**

b) $K.E = 0$, For $\frac{hc}{\lambda_0} - W_0 = 0 \Rightarrow \lambda_0 = \frac{hc}{W_0}$. **(1)**

3) a) $\lambda_0 = 0.66 \mu\text{m}$ **(3/4)**

b) Graphically we have :

For $\lambda = 0.18 \mu\text{m}$, $K.E = 5 \text{ eV} \Rightarrow 5 \times 1.6 \times 10^{-19} = \frac{hc}{0.18 \times 10^{-6}} - W_0$

For $\lambda = 0.66 \mu\text{m}$, $W_0 = \frac{hc}{0.66 \times 10^{-6}} \Rightarrow W_0 = 3 \times 10^{-19} \text{ J}$ and $h = 6.6 \times 10^{-34} \text{ J.s}$ **(1 1/2)**