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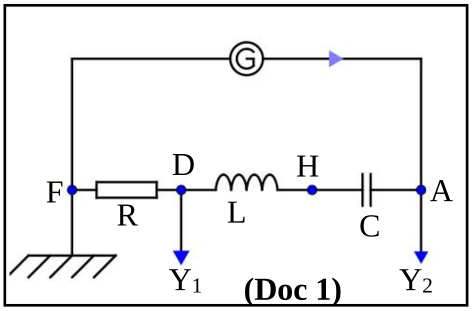
|---|---|---|
| المركز التربوي للبحوث والإنماء | الهيئة الأكاديميّة المشتركة<br>قسم: العلوم | المادة: الفيزياء<br>الشهادة: الثانوية العامّة<br>الفرع: علوم الحياة<br>نموذج رقم 2<br>المدّة: ساعتان |

**نموذج مسابقة (يراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)**

This test includes three mandatory exercises. The use of non-programmable calculators is allowed.

## Exercise 1 (7 points) Effect of the frequency on the current



(Doc 1)

The circuit, represented in the adjacent document (Doc 1), includes in series:

- A generator (G) delivering, across its terminals, an alternating voltage, $u_{AF} = u_G = 8\sin(2\pi ft)$ (S.I.);
- A capacitor of capacitance C = 0.265 μF;
- A coil of inductance L = 31.833 mH and of negligible resistance;
- A resistor of resistance R = 100 Ω.

The circuit carries then an alternating current i of expression:
$i = I_m \sin(2\pi ft + \varphi)$ (S.I.).

The aim of this exercise is to study the effect of the frequency f of $u_G$ on the amplitude $I_m$ of i and on the phase difference φ between i and $u_G$.

An oscilloscope, connected as shown in the document (Doc.1), is used to display the voltages $u_G$ and $u_R = u_{DF}$. The vertical sensitivity, of both channels, is the same in all the experiments: $S_V$ = 2 V/div.

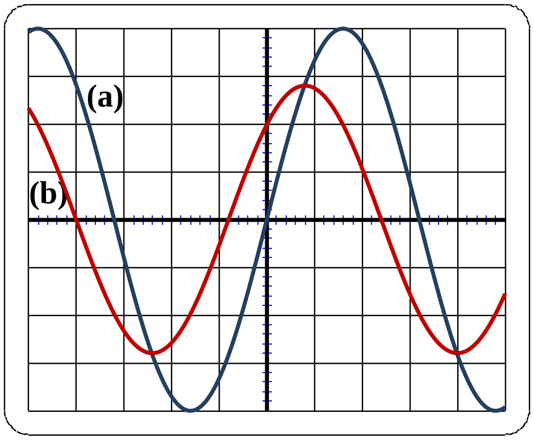
**1) 1rst experiment**

We set the frequency at $f = f_1$ = 1500 Hz. We observe on the screen of the oscilloscope the waveforms displayed in the adjacent document (Doc.2).

**1-1)** Identify the waveforms (a) and (b).

**1-2)** Determine the phase difference $\varphi_1$ between i and $u_G$.

**1-3)** Calculate the amplitude $I_{1m}$ of the current i.



**(Doc 2)**

**2) 2nd experiment.**

The frequency f is increased to $f = f_0$, $f_0$ being the proper frequency of the (RLC) series circuit.

We notice that the waveforms obtained coincide. The circuit is thus the seat of a certain phenomenon.

**2-1)** Give the name of the physical phenomenon obtained.

**2-2)** Give the value of the new phase difference $\varphi_2$ between i and $u_G$.

**2-3)** Deduce the value of $f_0$ and the new amplitude $I_{2m}$ of i.

**3) 3rd experiment**

**3-1)** We measure $I_m$ and φ for three other values of f; the results are tabulated as shown in the adjacent table (Doc 3). Complete this table.

| f (Hz) | 1000 | 1500 | $f_0$ =? | 2220 | 2500 |
|---|---|---|---|---|---|
| $I_m$ (A) | 0.02 | | | 0.04 | 0.03 |
| φ (rd) | -1.33 | | | 1.04 | 1.2 |

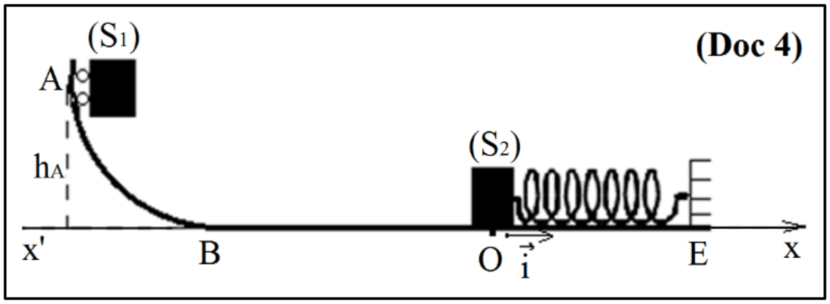
**(Doc 3)**

**3-2)** Referring to the table (Doc 3), draw the graph representing the variation of $I_m$ as a function of f.

**3-3)** Conclude about the effect of f on the amplitude $I_m$ of i and on the sign of the phase difference φ between i and $u_G$.

## Exercise 2 (7 points) Energies and collision

A particle ($S_1$), of mass $m_1$ = 200 g, is released from rest at the point A on a track ABOE, found in a vertical plane, as shown in the adjacent document (Doc 4).



The part AB, very smooth, along which we can neglect the force of friction, has the shape of a circular arc of radius $h_A$, and the part BO, a rough part, along which the force of friction $\vec{f}$ is supposed constant, is a rectilinear and horizontal path with BO = 1 m.

The particle ($S_1$) reaches the point B with the speed $v_{1B}$ = 4 m/s, then it covers the track BO to reach the point O with the speed $v_{1O}$ = 2 m/s.

At O, ($S_1$) enters into a head-on collision with a particle ($S_2$), of mass $m_2$ = 400 g, initially at rest and connected to the end of a horizontal spring of stiffness k = 100 N/m whose other end is fixed at E.

Take the horizontal plane containing BO as a gravitational potential energy reference level.

Take g = 10 m/$s^2$.

**1)** Conservation and non-conservation of the mechanical energy.

**1-1)** Applying the principle of conservation of the mechanical energy of the system [($S_1$), Earth], determine $h_A$.

**1-2)** Determine the work done by the force of friction $\vec{f}$ along BO.

**1-3)** Deduce the magnitude f of the force of friction $\vec{f}$ along BO.

**2)** Elastic collision.

The collision between the particles ($S_1$) and ($S_2$) is perfectly elastic. All the velocities, before and after the collision, are along the horizontal axis x'Ox.

**2-1)** Determine the speed $v'_{1O}$ of ($S_1$) and $v'_{2O}$ of ($S_2$) just after the collision.

**2-2)** Neglecting the force of friction between ($S_2$) and the track, just after the collision, calculate the maximum compression $x_m$ = OD of the spring.

**2-3)** In fact, the force of friction $\overrightarrow{f'}$ between ($S_2$) and the track, just after the collision, is not negligible and the maximum compression of the spring is $x'_m$ = OD' = 6.4 cm.

**2-3-1)** Determine the decrease in the mechanical energy of the system [($S_2$), Earth, spring], between O and D'.

**2-3-2)** In what form of energy does this decrease appear?

## Exercise 3 (6 points) Radioactivity of Thallium

The radioactive isotope of Thallium $^{207}_{81}Tl$ is a $\beta^-$emitter, of radioactive period 135 days. The disintegration of a Thallium 207 nucleus produces a daughter nucleus, the lead nucleus $^{A}_{Z}Pb$.The kinetic energy of the emitted $\beta^-$ particle is KE ($\beta^-$) = 0.70 MeV. This disintegration is accompanied by the emission of a gamma radiation ($\gamma$) of energy E($\gamma$), and an antineutrino$^{0}_{0}\bar{\nu}$ of energy E ($^{0}_{0}\bar{\nu}$) = 0.10 MeV.

The equation of disintegration is given by: $^{207}_{81}Tl \longrightarrow {}^{A}_{Z}Pb + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu} + \gamma$

Given:

m ($^{A}_{Z}Pb$) = 206.9759 u; m ($^{207}_{81}Tl$) = 206.9775 u; m ($^{0}_{-1}e$) = $5.486\times10^{-4}$ u;

1 u = 931.5 MeV/$c^2$; 1 eV = $1.6\times10^{-19}$ J; $N_A$ = $6.023\times10^{23}$.

**1)**

- **1-1)** Calculate A and Z specifying the used laws.
- **1-2)** Define the radioactive period of a substance.
- **1-3)** Calculate the decay constant λ of Thallium 207.
- **1-4)** Interpret the emission of the γ radiation.
- **1-5)** Knowing that the Thallium nucleus is initially at rest and the kinetic energy of the daughter nucleus is negligible, determine E (γ), the energy of the emitted photon γ.

**2)** In an energetic study concerning the $\beta^-$emission by a sample of 1 g of Thallium freshly prepared, an experimenter, during the first day of disintegration, detects the emitted electrons to determine the maximum average power produced by these electrons.

- **2-1)** Calculate the initial number of Thallium nuclei contained in this sample.
- **2-2)** Determine, in Bq, the initial value of the activity of this radioactive sample.
- **2-3)** During the first day:
  - **2-3-1)** Calculate the number of the emitted electrons.
  - **2-3-2)** Determine, in joules, the energy of the emitted $\beta^-$particles.
  - **2-3-3)** Deduce the average power of the emitted electrons.

المركز التربوي للبحوث والإنماء

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المادة: الفيزياء
الشهادة: الثانوية العامّة
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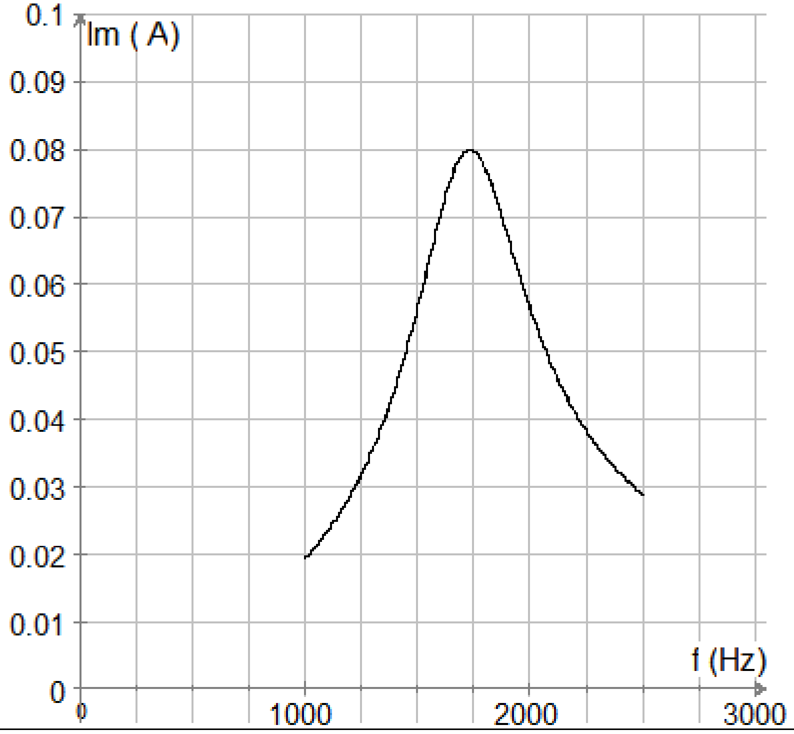
نموذج رقم 2
المدّة: ساعتان

أسس التصحيح (تراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

## Exercise 1 (7 points) Effect of the frequency on the intensity of current

<table>
<tr><th>Question</th><th>Answer</th><th>Mark</th></tr>
<tr><td>1-1</td><td>$U_{mG} > U_{mR}$ with the same vertical sensitivity, (a) represents $u_G$ and (b) represents $u_R$.</td><td>½</td></tr>
<tr><td>1-2</td><td>$|\varphi_1| = \frac{2\pi\times0.8}{6.4} = \frac{\pi}{4}$ rd<br>But the waveform (b) leads in phase the waveform (a), so $u_R$ (or i) leads $u_G$ because $u_R$ reaches the maximum value before $u_G$, then $\varphi_1 = +\frac{\pi}{4}$ rd.</td><td>½<br>½</td></tr>
<tr><td>1-3</td><td>$I_{1m} = U_{Rm}/R = 0.056$ A</td><td>½</td></tr>
<tr><td>2-1</td><td>Current resonance.</td><td>¼</td></tr>
<tr><td>2-2</td><td>$\varphi_2 = 0$</td><td>¼</td></tr>
<tr><td>2-3</td><td>$LC\omega^2 = 1$ with $\omega = 2\pi f_0$, then $f_0 = \frac{1}{2\pi\sqrt{LC}} = 1733$ Hz.<br>In case of current resonance, the circuit behaves as a pure resistor. So:<br>$I_{2m} = U_{mG}/R = 8/100 = 0.08$A</td><td>½<br>½<br>½</td></tr>
<tr><td>3-1</td><td>
<table>
<tr><td>f (Hz)</td><td>1000</td><td>1500</td><td>$f_0 = 1733$</td><td>2220</td><td>2500</td></tr>
<tr><td>$I_m$ (A)</td><td>0.02</td><td>0.056</td><td>0.08</td><td>0.04</td><td>0.03</td></tr>
<tr><td>φ (rd)</td><td>-1.33</td><td>-0.785</td><td>0</td><td>1.04</td><td>1.2</td></tr>
</table>
</td><td>½</td></tr>
<tr><td>3-2</td><td>
</td><td>1</td></tr>
<tr><td>3-3</td><td>When f increases, for $f < f_0$, $I_m$ increases and i leads $u_G$ in phase; $\varphi > 0$.<br>For $f = f_0$, $I_m$ takes a maximum value and i and $u_G$ are in phase; $\varphi = 0$.<br>When f increases, for $f > f_0$, $I_m$ decreases and i lags behind $u_G$ in phase; $\varphi < 0$.</td><td>½<br>½<br>½</td></tr>
</table>

**Exercise 2 (7 points) Energies and collisions**

| Question | Answer | Mark |
|---|---|---|
| 1-1 | ME(A) = ME(B)<br>$PE_g(A) + KE(A) = PE_g(B) + KE(B)$<br>$m_1gh_A + 0 = 0 + \frac{1}{2}m_1(v_{1B})^2$<br>$h_A = \frac{\frac{1}{2}(v_{1B})^2}{g}$<br>$h_A = \frac{\frac{1}{2}(4)^2}{10}$<br>$h_A = 0.8$ m | ½<br>¾ |
| 1-2 | Explanation:<br>$ME(O) – ME(B) = W(\vec{f})_{B\to O}$<br>$PE_g(O) + KE(O) – PE_g(B) – KE(B) = W(\vec{f})_{B\to O}$<br>$0 + \frac{1}{2}m_1(v_{1O})^2 – 0 – \frac{1}{2}m_1(v_{1B})^2 = W(\vec{f})_{B\to O}$<br>$W(\vec{f})_{B\to O} = \frac{1}{2} \times 0.2 \times (2)^2 – 0 – \frac{1}{2} \times 0.2 \times (4)^2$<br>$W(\vec{f}))_{B\to O} = -1.2$ J | ½<br>¾ |
| 1-3 | $W(\vec{f})_{B\to O} = \vec{f}.\overrightarrow{BO} = - f \times BO$<br>$f = -\frac{W(\vec{f})_{B\to O}}{BO}$<br>$f = -\frac{-1.2}{1} = 1.2$ N | 1 |
| 2-1 | During the collision, the linear momentum of the system [($S_1$),($S_2$)] is conserved:<br>$\vec{p}_{before} = \vec{p}_{after}$<br><br>In algebraic values along the positive direction:<br>$m_1v_{1O} +0 = m_1v'_{1O} + m_2v'_{2O}$<br>$m_1 (v_{1O} –v'_{1O}) = m_2v'_{2O}$ (equation 1)<br><br>The collision being elastic, then the kinetic energy of the system is conserved:<br>$KE_{before} = KE_{after}$<br>$\frac{1}{2}m_1(v_{1O})^2 + 0 =\frac{1}{2}m_1(v'_{1O})^2 + \frac{1}{2}m_2(v'_{2O})^2$<br>$m_1(v_{1O} – v'_{1O})(v_{1O}+ v'_{1O}) = m_2(v'_{2O})^2$ (equation 2)<br><br>Using both equations, (equation 2) and (equation 1), we get:<br>$v_{1O} + v'_{1O} = v'_{2O}$ (equation 3)<br><br>Using the equations, (equation 1) and (equation 3), we get :<br>$v'_{1O} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{1O}$<br><br>Which gives: $v'_{1O} = -2/3 = -0.67$ m/s<br>then replace in (equation 3), we get: $v'_{2O} = 4/3 = 1.33$ m/s. | 1<br>½ |

| | | |
|---|---|---|
| 2-2 | The mechanical energy of the system [($S_2$), spring, Earth] is conserved.<br>ME(O) = ME(D)<br>$PE_g(O) + PE_e(O) + KE(O) = PE_g(D) + PE_e(D) + KE(D)$<br>$0 + 0 + ½m_2(v'_{2O})^2 = 0 + ½k(x_m)^2 + 0$<br>$m_2(v'_{2O})^2 = k(x_m)^2$<br>$x_m = (v'_{2O})\sqrt{\frac{m_2}{k}}$<br>$x_m = \frac{4}{3}\sqrt{\frac{0.4}{100}}$<br>$x_m$= OD = 0.084 m = 8.4 cm | ½<br>½ |
| 2-3-1 | The decrease in the mechanical energy of the system [($S_2$), Earth, spring] is equal to:<br>$\lvert \Delta ME \rvert = ½m_2(v'_{2O})^2 – ½k(x'_m)^2 = ½ \times 0.4 \times (4/3)^2 – ½ \times 100 \times (0.064)^2 = 0.15$ J | ½ |
| 2-3-2 | This decrease appears in the form of thermal energy (heat). | ½ |

## Exercise 3 (6 points) Radioactivity of Thallium

| Question | Answer | Mark |
|---|---|---|
| 1-1 | By applying Soddy's laws:<br>Conservation of the mass number: 207 = A + 0 + 0 ⇒ A = 207<br>Conservation of the charge number: 81 = Z – 1 + 0 ⇒ Z = 82 | ¼<br>¼<br>¼ |
| 1-2 | The radioactive period of a substance is the time interval at the end of which the activity becomes equal to half of its initial value. | ½ |
| 1-3 | $\lambda = \frac{\ln 2}{T} = \frac{0.693}{135 \times 24 \times 3600} = 5.94 \times 10^{-8} s^{-1}$ | ½ |
| 1-4 | The Lead daughter nucleus, produced by the decay, is obtained in an excited state; it will last, in this state, for a short time, after which, it undergoes a downward transition and this de-excitation is accompanied by the emission of a γ radiation. | ¼ |
| 1-5 | The law of conservation of total energy:<br>$m(Tl).c^2 = m(Pb).c^2 + m(e^-).c^2 + KE(e^-) + E(\gamma) + E\ ({}^0_0\bar{\nu})$<br>so $\Delta m.c^2 = (206.9775 – 206.9759 – 5.486\times10^{-4}) \times 931.5$<br>and $\Delta m.c^2 = 0.70 + E(\gamma) + 0.10$<br>then: $E(\gamma)$= 0.97938 – 0.80 = 0.179 MeV | ½<br>½ |
| 2-1 | $\frac{m}{M} = \frac{N_0}{N_A}$ then $N_0 = 2.9096 \times 10^{21}$ nuclei. | ½ |
| 2-2 | $A_0 = \lambda N_0 = 5.94\times10^{-8} \times 2.9096\times10^{21} = 1.7283\times10^{14}$ Bq | ½ |
| 2-3-1 | The number of nuclei of thallium remaining at the end of one day:<br>$N_1 = N_0e^{-\lambda t} = 2.9096 \times 10^{21}e^{(-5.94\times10^{-8}\times24\times3600)} = 2.8947\times10^{21}$ nuclei<br>The number of disintegrated nuclei is: $N = N_0 – N_1 = 1.49\times10^{19}$ nuclei<br>But the number of emitted electrons is equal to the number of disintegrated nuclei<br>Then: $N_{e-} = 1.49\times10^{19}$ electrons | ½<br>½ |
| 2-3-2 | $E = N_{e-} \times KE(\beta^-) = 1.49\times10^{19} \times 0.70 = 1.043\times10^{19}$ MeV = $1.668\times10^6$ J | ½ |
| 2-3-3 | $P_{av} = E/\Delta t = 1.668\times10^6/(24 \times 3600) = 19.3$ W | ½ |