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

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

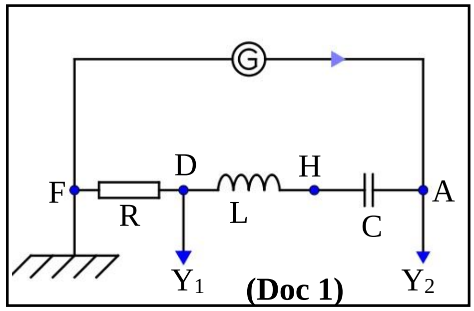
المرجع: دورة سنة 2012 الإستثنائية الإكمالية (معدّلة بحسب توصيف مادة الفيزياء للعام الدراسي 2016-2017)

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

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.



(Doc 1)

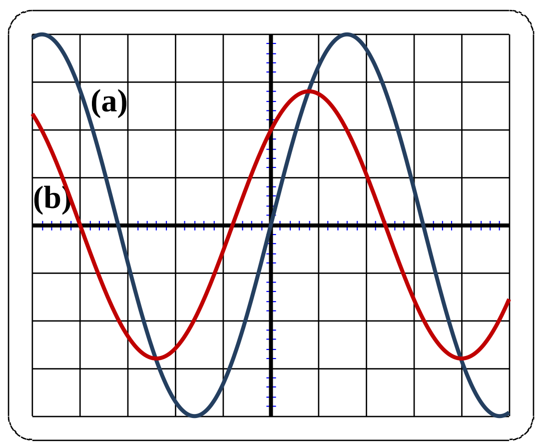
The circuit carries then an alternating current i of expression:
$i = I_m \sin(2\pi ft + \varphi)$ (S.I.).

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) 1^rst^ 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).



(Doc 2)

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

1-2) Determine the phase difference φ_1 between i and u_G.

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

2) 2^nd^ 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 φ_2 between i and u_G.

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

3) 3^rd^ 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.

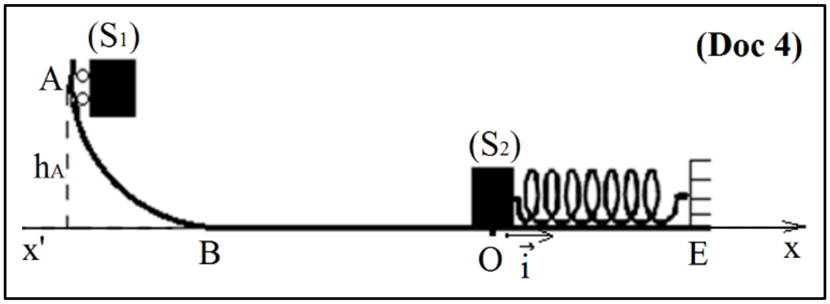
f (Hz)	1000	1500	f_0 =?	2220	2500
I_m (A)	0.02			0.04	0.03
φ (rd)	1.33			-1.04	-1.2

(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 ${}^{207}_{81}\mathrm{Tl}$ is a β^-emitter, of radioactive period 135 days. The disintegration of a Thallium 207 nucleus produces a daughter nucleus, the lead nucleus ${}^{A}_{Z}\mathrm{Pb}$.The kinetic energy of the emitted β^- particle is KE (β^-) = 0.70 MeV. This disintegration is accompanied by the emission of a gamma radiation (γ) of energy E(γ), and an antineutrino ${}^{0}_{0}\bar{\nu}$ of energy E (${}^{0}_{0}\bar{\nu}$) = 0.10 MeV.
The equation of disintegration is given by: ${}^{207}_{81}\mathrm{Tl} \longrightarrow {}^{A}_{Z}\mathrm{Pb} + {}^{0}_{-1}\mathrm{e} + {}^{0}_{0}\bar{\nu} + \gamma$
Given:

m (${}^{A}_{Z}\mathrm{Pb}$) = 206.9759 u;	m (${}^{207}_{81}\mathrm{Tl}$) = 206.9775 u;	m (${}^{0}_{-1}\mathrm{e}$) = 5.486×10^{-4} u;
1 u = 931.5 MeV/c^2;	1 eV = 1.6×10^{-19} J;	N_A = 6.023×10^{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 β^-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 β^-particles.
2-3-3) Deduce the average power of the emitted electrons.

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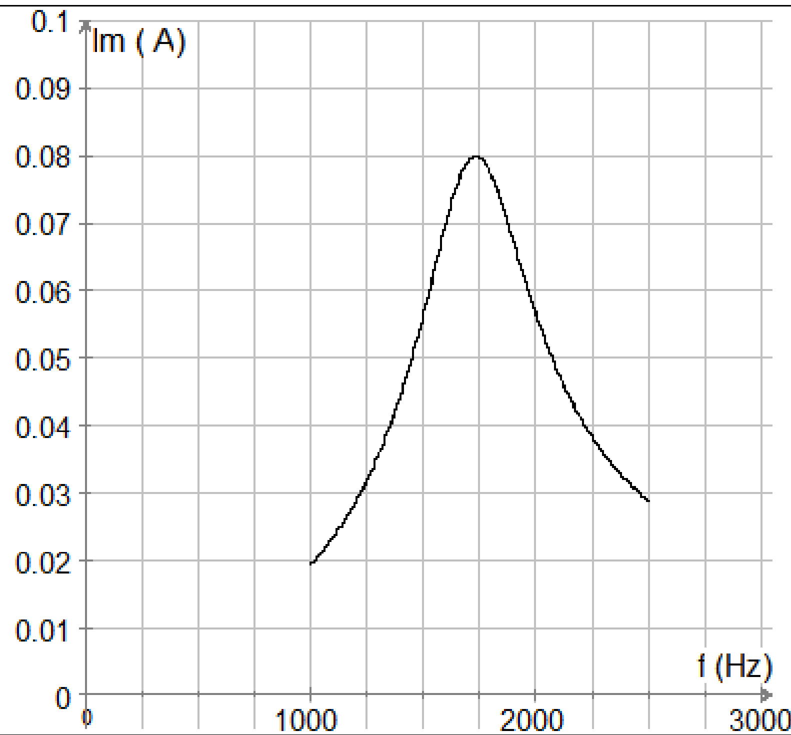
أسس التصحيح (تراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

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
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
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.
In case of current resonance, the circuit behaves as a pure resistor. So:
$I_{2m} = U_{mG}/R = 8/100 = 0.08$A</td><td>½
½
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; $\varphi > 0$.
For $f = f_0$, I_m takes a maximum value and i and u_G are in phase; $\varphi = 0$.
When f increases, for $f > f_0$, I_m decreases and i lags behind u_G in phase; $\varphi < 0$.</td><td>½
½
½</td></tr>
</table>

Exercise 2 (7 points) Energies and collisions

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

2-2	The mechanical energy of the system [(S_2), spring, Earth] is conserved. ME(O) = ME(D) $PE_g(O) + PE_e(O) + KE(O) = PE_g(D) + PE_e(D) + KE(D)$ $0 + 0 + ½m_2(v'_{2O})^2 = 0 + ½k(x_m)^2 + 0$ $m_2(v'_{2O})^2 = k(x_m)^2$ $x_m = (v'_{2O})\sqrt{\frac{m_2}{k}}$ $x_m = \frac{4}{3}\sqrt{\frac{0.4}{100}}$ x_m= OD = 0.084 m = 8.4 cm	½ ½
2-3-1	The decrease in the mechanical energy of the system [(S_2), Earth, spring] is equal to: $\lvert\Delta ME\rvert = ½m_2(v'_{2O})^2 - ½k(x'_m)^2 = ½ \times 0.4 \times (4/3)^2 - ½ \times 100 \times (0.064)^2 = 0.15$ 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: Conservation of the mass number: 207 = A + 0 + 0 $\Rightarrow$ A = 207 Conservation of the charge number: 81 = Z – 1 + 0 $\Rightarrow$ Z = 82	¼ ¼ 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: $m(Tl).c^2 = m(Pb).c^2 + m(e^-).c^2 + KE(e^-) + E(\gamma) + E(^0_0\bar{\nu})$ so $\Delta m.c^2 = (206.9775 - 206.9759 - 5.486\times10^{-4}) \times 931.5$ and $\Delta m.c^2 = 0.70 + E(\gamma) + 0.10$ then: $E(\gamma)$= 0.97938 – 0.80 = 0.179 MeV	½ 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: $N_1 = N_0 e^{-\lambda t} = 2.9096 \times 10^{21} e^{(-5.94\times10^{-8}\times24\times3600)} = 2.8947\times10^{21}$ nuclei The number of disintegrated nuclei is: $N = N_0 - N_1 = 1.49\times10^{19}$ nuclei But the number of emitted electrons is equal to the number of disintegrated nuclei Then: $N_{e-} = 1.49\times10^{19}$ electrons	½ 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