

المادة: الفيزياء الشهادة: الثانوية العامة الفرع: علوم الحياة نموذج رقم 2 المدة: ساعتان	الهيئة الأكاديمية المشتركة قسم: العلوم	 المركز الوطني للبحوث والابتاء
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نموذج مسابقة (يراعي تعليق الدروس والتوصيف المعدل للعام الدراسي 2016-2017 وحتى صدور المناهج المطورة)
المرجع: دورة سنة 2012 الإستثنائية الإكمالية (معدلة 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:

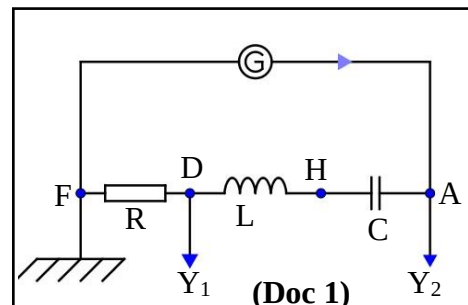
- A generator (G) delivering, across its terminals, an alternating voltage, $u_{AF} = u_G = 8\sin(2\pi ft)$ (S.I.);
- A capacitor of capacitance $C = 0.265 \mu\text{F}$;
- A coil of inductance $L = 31.833 \text{ mH}$ and of negligible resistance;
- A resistor of resistance $R = 100 \Omega$.

The circuit carries then an alternating current i of expression:

$$i = I_m \sin(2\pi ft + \phi) \text{ (S.I.)}$$

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: $S_V = 2 \text{ V/div}$.



1) 1st experiment

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

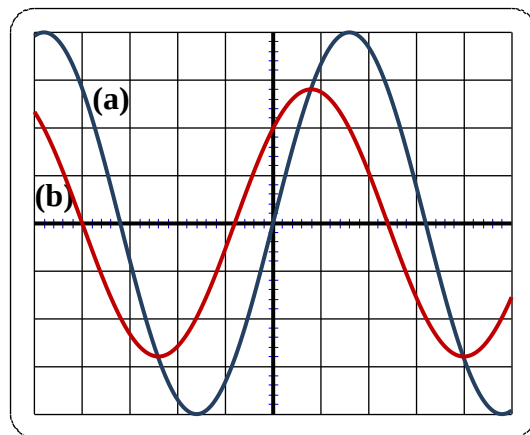
- 1-1) Identify the waveforms (a) and (b).
- 1-2) Determine the phase difference ϕ_1 between i and u_G .
- 1-3) Calculate the amplitude I_{1m} of the current i .

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 ϕ_2 between i and u_G .
- 2-3) Deduce the value of f_0 and the new amplitude I_{2m} of i .



(Doc 2)

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.

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 .

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)

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,

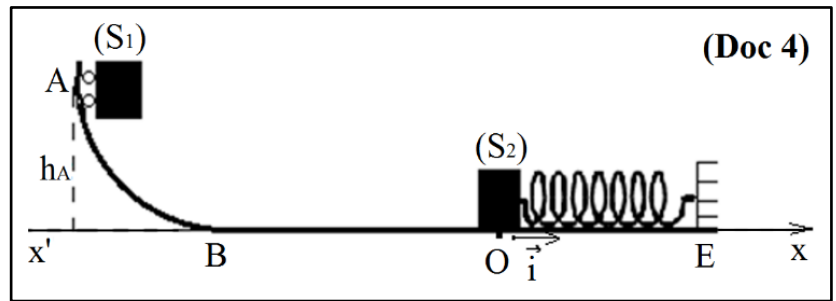
is a rectilinear and horizontal path with $BO = 1$ m.

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/s².



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 $\vec{f}'$ 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 $^{207}_{81}\text{Tl}$ is a β^- -emitter, of radioactive period 135 days. The disintegration of a Thallium 207 nucleus produces a daughter nucleus, the lead nucleus $^{207}_{82}\text{Pb}$. The kinetic energy of the emitted β^- particle is $KE(\beta^-) = 0.70$ MeV. This disintegration is accompanied by the emission of a gamma radiation (γ) 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: $^{207}_{81}\text{Tl} \longrightarrow ^{207}_{82}\text{Pb} + ^0_{-1}\text{e} + ^0_0\bar{\nu} + \gamma$

Given:

$$\begin{array}{lll} m(^{207}_{82}\text{Pb}) = 206.9759 \text{ u}; & m(^{207}_{81}\text{Tl}) = 206.9775 \text{ u}; & m(^0_{-1}\text{e}) = 5.486 \times 10^{-4} \text{ u}; \\ 1 \text{ u} = 931.5 \text{ MeV}/c^2; & 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}; & N_A = 6.023 \times 10^{23}. \end{array}$$

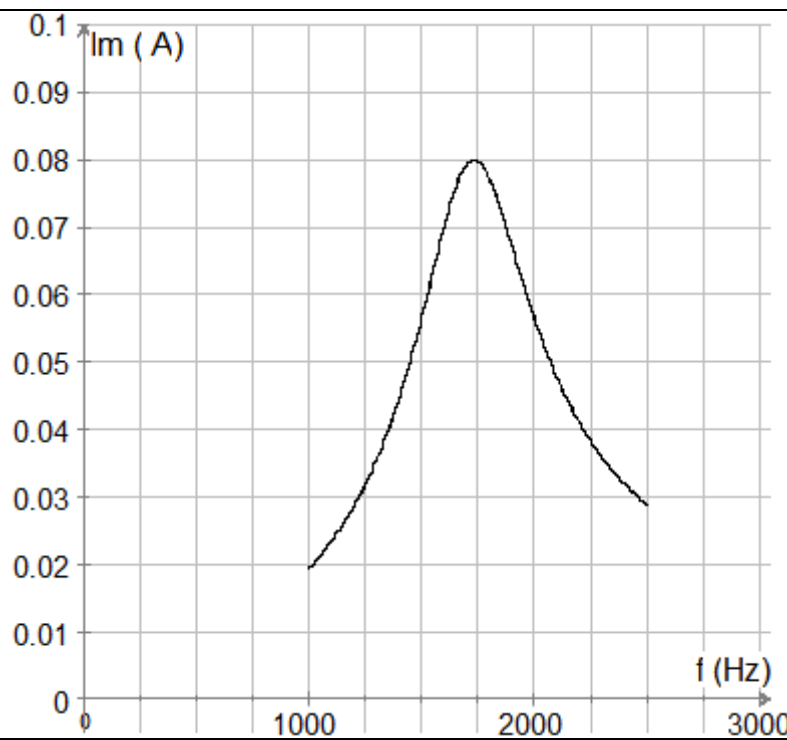
- 1)
 - 1-1) Calculate A and Z specifying the used laws.
 - 1-2) Define the radioactive period of a substance.
 - 1-3) Calculate the decay constant λ of Thallium 207.
 - 1-4) Interpret the emission of the γ radiation.
 - 1-5) Knowing that the Thallium nucleus is initially at rest and the kinetic energy of the daughter nucleus is negligible, determine $E(\gamma)$, 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 المعدل للعام الدراسي 2016-2017 وحتى صدور المناهج المطورة)

Exercise 1 (7 points)

Effect of the frequency on the intensity of current

Question	Answer	Mark																		
1-1	$U_{mG} > U_{mR}$ with the same vertical sensitivity, (a) represents u_G and (b) represents u_R .	$\frac{1}{2}$																		
1-2	$ \varphi_1 = \frac{2\pi \times 0.8}{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.	$\frac{1}{2}$																		
1-3	$I_{1m} = U_{Rm}/R = 0.056$ A	$\frac{1}{2}$																		
2-1	Current resonance.	$\frac{1}{4}$																		
2-2	$\varphi_2 = 0$	$\frac{1}{4}$																		
2-3	$LC\omega^2 = 1$ 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	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$																		
3-1	<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>	f (Hz)	1000	1500	$f_0 = 1733$	2220	2500	I_m (A)	0.02	0.056	0.08	0.04	0.03	φ (rd)	-1.33	-0.785	0	1.04	1.2	$\frac{1}{2}$
f (Hz)	1000	1500	$f_0 = 1733$	2220	2500															
I_m (A)	0.02	0.056	0.08	0.04	0.03															
φ (rd)	-1.33	-0.785	0	1.04	1.2															
3-2		1																		
3-3	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; $\varphi < 0$.	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{1}{2}$																		

Energies and collisions

Question	Answer	Mark
1-1	$\text{ME(A)} = \text{ME(B)}$ $\text{PE}_g(\text{A}) + \text{KE}(\text{A}) = \text{PE}_g(\text{B}) + \text{KE}(\text{B})$ $m_1gh_A + 0 = 0 + \frac{1}{2}m_1(v_{1B})^2$ $h_A = \frac{\frac{1}{2}(v_{1B})^2}{g}$ $h_A = \frac{\frac{1}{2}(4)^2}{10}$ $h_A = 0.8 \text{ m}$	1/2 3/4
1-2	Explanation: $\text{ME(O)} - \text{ME(B)} = W(\vec{f})_{\text{B} \rightarrow \text{O}}$ $\text{PE}_g(\text{O}) + \text{KE}(\text{O}) - \text{PE}_g(\text{B}) - \text{KE}(\text{B}) = W(\vec{f})_{\text{B} \rightarrow \text{O}}$ $0 + \frac{1}{2}m_1(v_{1O})^2 - 0 - \frac{1}{2}m_1(v_{1B})^2 = W(\vec{f})_{\text{B} \rightarrow \text{O}}$ $W(\vec{f})_{\text{B} \rightarrow \text{O}} = \frac{1}{2} \times 0.2 \times (2)^2 - 0 - \frac{1}{2} \times 0.2 \times (4)^2$ $W(\vec{f})_{\text{B} \rightarrow \text{O}} = -1.2 \text{ J}$	1/2 3/4
1-3	$W(\vec{f})_{\text{B} \rightarrow \text{O}} = \vec{f} \cdot \overrightarrow{\text{BO}} = -f \times \text{BO}$ $f = -\frac{W(\vec{f})_{\text{B} \rightarrow \text{O}}}{\text{BO}}$ $f = -\frac{-1.2}{1} = 1.2 \text{ N}$	1
2-1	During the collision, the linear momentum of the system [(S₁),(S₂)] is conserved: $\vec{p}_{\text{before}} = \vec{p}_{\text{after}}$ 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: $\text{KE}_{\text{before}} = \text{KE}_{\text{after}}$ $\frac{1}{2}m_1(v_{1O})^2 + 0 = \frac{1}{2}m_1(v'_{1O})^2 + \frac{1}{2}m_2(v'_{2O})^2$ $m_1(v_{1O} - v'_{1O})(v_{1O} + v'_{1O}) = m_2(v'_{2O})^2$ (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: $v'_{1O} = -2/3 = -0.67 \text{ m/s}$ then replace in (equation 3), we get: $v'_{2O} = 4/3 = 1.33 \text{ m/s}$.	1 1/2

2-2	The mechanical energy of the system [(S₂), 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 + ½m₂(v'_{2O})² = 0 + ½k(x_m)² + 0 m₂(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 [(S₂), Earth, spring] is equal to: ΔME = ½m₂(v'_{2O})² - ½k(x'_m)² = ½ × 0.4 × (4/3)² - ½ × 100 × (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 ⇒ A = 207 Conservation of the charge number: 81 = Z - 1 + 0 ⇒ 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	$\lambda = \frac{\ln 2}{T} = \frac{0.693}{135 \times 24 \times 3600} = 5.94 \times 10^{-8} \text{ s}^{-1}$	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).c² = m(Pb).c² + m(e⁻).c² + KE(e⁻) + E(γ) + E(⁰ν̄) so Δm.c² = (206.9775 - 206.9759 - 5.486 × 10⁻⁴) × 931.5 and Δm.c² = 0.70 + E(γ) + 0.10 then: E(γ) = 0.97938 - 0.80 = 0.179 MeV	½ ½
2-1	$\frac{m}{M} = \frac{N_0}{N_A}$ then N ₀ = 2.9096 × 10 ²¹ nuclei.	½
2-2	A ₀ = λN ₀ = 5.94 × 10 ⁻⁸ × 2.9096 × 10 ²¹ = 1.7283 × 10 ¹⁴ Bq	½
2-3-1	The number of nuclei of thallium remaining at the end of one day: N₁ = N₀e^{-λt} = 2.9096 × 10²¹ e^(-5.94 × 10⁻⁸ × 24 × 3600) = 2.8947 × 10²¹ nuclei The number of disintegrated nuclei is: N = N₀ - N₁ = 1.49 × 10¹⁹ nuclei But the number of emitted electrons is equal to the number of disintegrated nuclei Then: N_{e⁻} = 1.49 × 10¹⁹ electrons	½ ½
2-3-2	E = N _{e⁻} × KE(β ⁻) = 1.49 × 10 ¹⁹ × 0.70 = 1.043 × 10 ¹⁹ MeV = 1.668 × 10 ⁶ J	½
2-3-3	P _{av} = E/Δt = 1.668 × 10 ⁶ / (24 × 3600) = 19.3 W	½