This exam is formed of three obligatory exercises in 3 pages.
The use of non-programmable calculator is recommended

Exercise 1 (6.5 points)

Determination of the capacitance of a capacitor

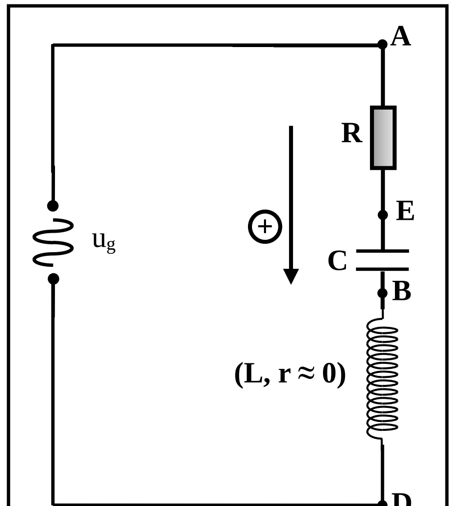
The aim of this exercise is to determine the capacitance C of a capacitor. For this aim, consider the electric circuit shown in document 1. The circuit includes a resistor of resistance R, a coil of inductance L and of negligible resistance r, a capacitor of capacitance C, and a low frequency generator (LFG) delivering alternating sinusoidal voltage:

$u_g = u_{AD} = U_m \cos(\omega t)$ (u in V ; t in s).

An oscilloscope is connected so as to visualize, as a function of time, the variation of the voltage u_{AD} across the generator on channel Y_1 and the voltage $u_{BD} = u_{coil}$ across the coil on channel Y_2 (Document 2).

The vertical sensitivity of channel 1 is: $Sv_1 = 5$ V/div.

The vertical sensitivity of channel 2 is: $Sv_2 = 2$ V/div.



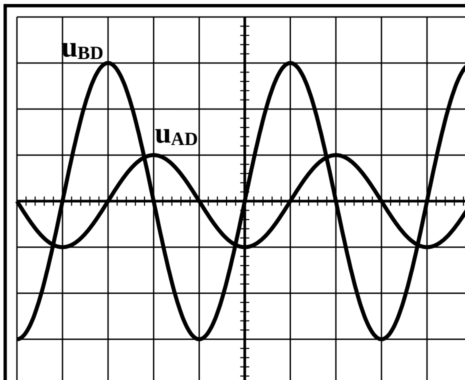
Doc. 1

1) Redraw the circuit of document 1 showing on it the connections of the oscilloscope.

2) Using the waveforms of document 2, determine:

2-1) the amplitudes U_m and $U_{m(coil)}$ of the voltages u_g and u_{coil}.

2-2) the phase difference between the two voltages.



Doc.2

3) Write the expression of the voltage u_{coil} across the coil as function of time t and the angular frequency ω.

4) The expression of the current i in the circuit is:

$i = \frac{9.375\pi}{\omega}\cos(\omega t)$ (i in A ; t in s).

Determine the expression of the voltage u_{coil} across the terminals of the coil in terms of L, ω and t.

5) Using the results of part 3 and 4, show that L = 0.204 H.

6) Indicate the value of the phase difference between u_g and i.

7) A phenomenon takes place in the circuit. Name this phenomenon.

8) Deduce the value of C knowing that the angular frequency $\omega = 300\pi$ rad/s.

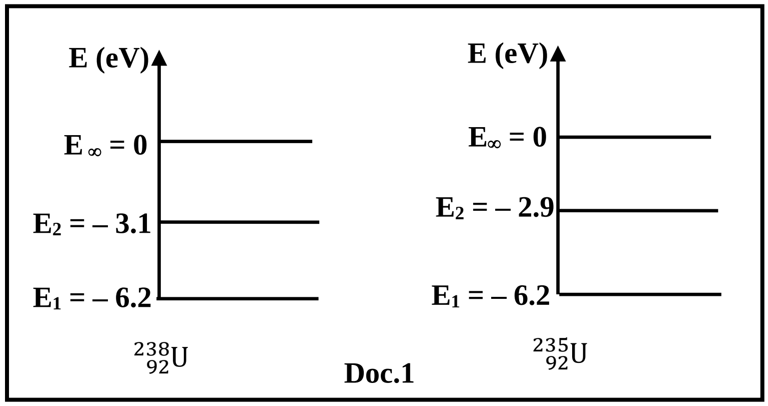
Exercise 2 **(6.5 points)**

Ionization and fission of uranium

The aim of this exercise is to study the ionization and the fission of a uranium isotope.
Given:
1 eV = 1.6×10^{-19} J ; speed of light in vacuum: $c = 3\times10^{8}$ m/s ; Planck's constant: $h = 6.6\times10^{-34}$ J.s.
Mass of $^{235}_{92}U$ nucleus = 234.99342 u ; 1u = 1.66×10^{-27} kg.

1- Ionizing one of the uranium isotopes

A monochromatic radiation of frequency $\nu = 8\times10^{14}$ Hz illuminates a sample of uranium containing the isotopes $^{235}_{92}U$ and $^{238}_{92}U$.



Doc.1

1-1) Calculate, in Joules and in eV, the energy of a photon of the incident radiation.

1-2) Document 1 shows some of the energy levels of the isotopes $^{235}_{92}U$ and $^{238}_{92}U$.
The photons of the incident radiation can excite one of these isotopes of uranium from energy level E_1 to energy level E_2.
Specify which of the two isotopes will be excited.

1-3) Before it de-excites, the excited isotope receives another photon of same frequency ν.

1-3-1) Show that this isotope will be ionized.

1-3-2) Determine the maximum kinetic energy KE_{max} of the liberated electron.

1-4) This experiment shows evidence of one of the two aspects of light. Name this aspect.

2- Nuclear reaction

The isotope of uranium which undergoes fission in the nuclear power plant is uranium-235.
One of the fission reactions of uranium-235 nucleus is given by:

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{90}_{36}Kr + ^{X}_{56}Ba + 8\,^{1}_{0}n + \gamma$$

2-1) This reaction is provoked. Why?

2-2) What condition must the projectile satisfy in order to realize this reaction?

2-3) Use one of the conservation laws to calculate x.

2-4) The energy liberated by the fission of each nucleus of uranium-235 is about 200 MeV. In what forms does this energy appear?

2-5) A nuclear power plant of efficiency 40 % furnishes an electric power 600 MW.
Determine, in kg, the mass of uranium-235 consumed in 1 day in this power plant.

Exercise 3 **(7 points)**

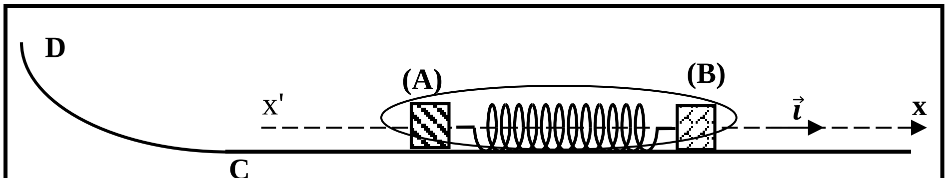
Determination of the mass of a block and the stiffness of a spring

Consider two blocks, (A) of unknown mass m_A and (B) of mass m_B = 0.8 kg, and a spring (R) of negligible mass and of stiffness k. The aim of this exercise is to determine m_A and k.
Neglect all the forces of friction and take $g = 10\ m/s^2$.

1- First experiment: Determination of m_A

The spring is placed on a horizontal track. The spring is compressed between (A) and (B) by means of a light string (Document 1).

The center of mass of (A) and that of (B) belong to the same horizontal plane which is taken as a reference level for gravitational potential energy.
The x-axis extends positively to the right.
We burn the string, (A) and (B) are ejected in opposite directions.



Doc. 1

1-1) Name the external forces acting on the system [(A), (B) and (R)].

1-2) Deduce that the linear momentum of the system [(A), (B) and (R)] is conserved during the motion of (A) and (B) on the horizontal track.

1-3) The velocity of the center of mass of block (B) just after ejection is $\vec{V}_B = 0.75\,\vec{i}$ (m/s).

1-3-1) Determine the linear momentum $\vec{P}_A$ of block (A).

1-3-2) Deduce in terms of m_A the velocity $\vec{V}_A$ of the center of mass of (A) just after ejection.

1-4) Block (A) continues its motion and reaches a curvilinear path CD situated in the vertical plane (Document 1). The maximum height attained by the center of mass of (A) above the reference level is $h_{max} = 5$ cm.

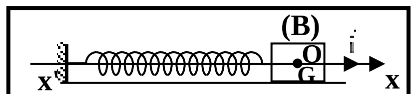
1-4-1) Apply the principle of conservation of mechanical energy to the system [(A), Earth] to determine the magnitude V_A of $\vec{V}_A$.

1-4-2) Deduce the value of the mass m_A.

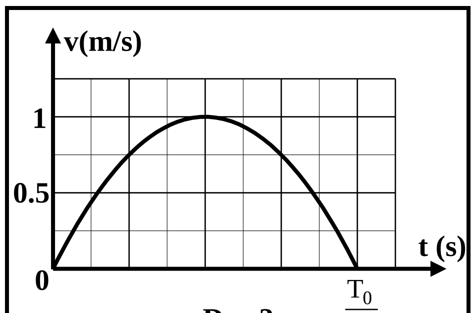
2- Second experiment: Determination of k

We fix block (B) to one of the ends of the spring (R), the other end of the spring is attached to a fixed support (Document 2).
At equilibrium, (B) is at O taken as an origin of abscissa of the axis x'x.
(B) is displaced, from point O along the axis x'x by a distance X_m in the negative direction, and then it is released without initial velociy at the instant $t_0 = 0$. At an instant t, the abscissa of the center of mass G of (B) is x and the algebraic measure of its velocity is v.

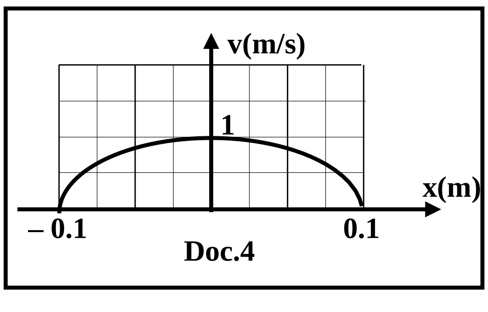
During the motion of (B) between $t_0 = 0$ and $t = \frac{T_0}{2}$ [T_0 is the proper period of the oscillations of (B)], an appropriate system traces the graphs of documents (3) and (4).
Document (3): represents the variation of the speed of G as a function of time.
Document (4): represents the variation of the speed of G as a function of the abscissa x.



Doc.2



Doc.3



Doc.4

2-1) Determine, by referring to document (3), the value of the maximum kinetic energy of (B).

2-2) Deduce the value of the maximum elastic potential energy of the system [(R), (B), Earth].

2-3) Indicate, by referring to document (4), the value of X_m.

2-4) Deduce the value of k.

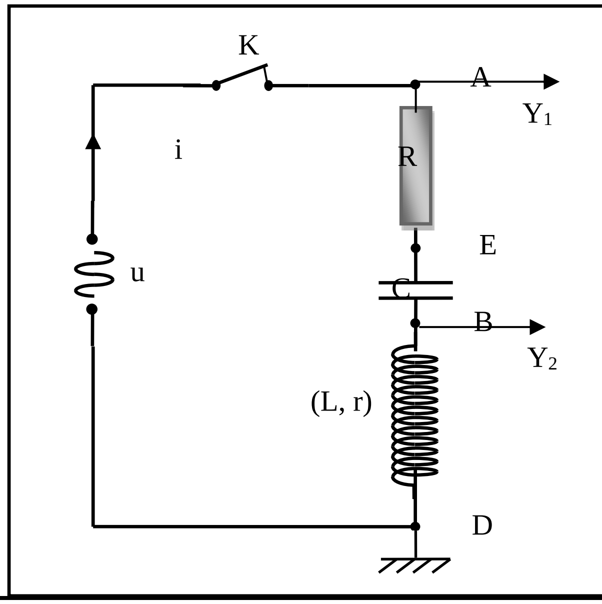
وزارة التربية والتعليم العالي
المديرية العامة للتربية
دائرة الامتحانات الرسميّة

امتحانات الشهادة الثانوية العامة
الفرع: علوم الحياة

دورة العام 2017 الاستثنائيّة
الاثنين في 7 آب 2017

مسابقة في مادة الفيزياء المدة: ساعتان	الاسم: الرقم:

Exercise 1 : Determination the capacitance of a capacitor

Question	Answer		mark
1			0.5
2	2-1	$U_{\max(g)} = y \times Sv_1 = 5V$ $U_{\max(l)} = y \times Sv_2 = 6V$	0.5 0.5
	2-2	$\Delta\emptyset = \frac{2\pi d}{D} = \frac{\pi}{2} rad.$	0.5
3	$u_{coil} = 6\,cos(\omega t + \frac{\pi}{2})$ = - 6 sin (ωt)		0.75
4	u_{coil} = $L\frac{di}{dt}$ = - L × 9.375 π sin(ωt).		1
5	u_{coil}= u_{coil} , then 6 = L ×9.375 π ; then L = 0.204 H.		1
6	zero		0.5
7	Current resonance		0.5
8	Current resonance, $LC(\omega)^2 = 1, \;\; C = 5.518\ \mu F.$		0.75

<table>
<tr><th colspan="5"><u>Exercise 2</u> : Ionization and fission of uranium</th></tr>
<tr><th colspan="3">Question</th><th>Answer</th><th>mark</th></tr>
<tr><td rowspan="6">1</td><td colspan="2">1</td><td>$E = h\nu$
$E = 6.6\times10^{-34}\times8\times10^{14} = 5.28\times10^{-19}$ J
$E = 3.3$ eV</td><td>0.25
0.5
0.25</td></tr>
<tr><td colspan="2">2</td><td>$E = 3{,}3$ eV $= E_2 - E_1$ for ${}^{235}_{92}U$
${}^{235}_{92}U$ can be excited</td><td>0.5
0.25</td></tr>
<tr><td rowspan="2">3</td><td>1</td><td>$E_{ionisation} = E_\infty - E_2 = 2{,}9$ eV
$E_{photon} > 2.9$ eV, the isotope can be ionized</td><td>0.25
0.5</td></tr>
<tr><td>2</td><td>$E_{photon} = (E_\infty - E_2) + K.E_{max} = E_{ionisation} + K.E_{max}$
$K.E_{max} = 0.4$ eV</td><td>0.5
0.5</td></tr>
<tr><td colspan="2">4</td><td>Aspect corpuscular of light</td><td>0.25</td></tr>
<tr><td rowspan="5">2</td><td colspan="2">1</td><td>Since it has an external intervention (bombarded by a neutron)</td><td>0.25</td></tr>
<tr><td colspan="2">2</td><td>Thermal neutron <u>or</u> slow neutron <u>or</u> KE ≈ 0.025 eV</td><td>0.25</td></tr>
<tr><td colspan="2">3</td><td>Law of conservation of mass number: x = 138</td><td>0.5</td></tr>
<tr><td colspan="2">4</td><td>Kinetic energy of emitted nuclei, KE of emitted particles, energy of photons γ</td><td>0.5</td></tr>
<tr><td colspan="2">5</td><td>$E_{elect} = P\times t = 600\times10^{6}\times24\times3600 = 5.184\times10^{13}$ J
efficiency $= \frac{E_{'electrique}}{E_{nucléaire}}$; $E_{nuclear} = E_{elect}\frac{100}{40} = 1.296\times10^{14}$ J
$m({}^{235}_{92}U) = 234.99342$ u $= 234.99342\times1{,}66\times10^{-27}$ kg $= 3.90\times10^{-25}$ kg
200 MeV $= 200\times1{,}6\times10^{-13}$ J $= 3.20\times10^{-11}$ J
$m_{totale} = \frac{1.296\times10^{14}\times3.90\times10^{-25}}{3.20\times10^{-11}} = 1.58$ kg</td><td>1.25</td></tr>
</table>

Exercise 3 : Determination of the mass of a block and the stiffness of a spring				
Question			**Answer**	**Mark**
1	1-1		Weight $m_A\vec{g}$ of (A), normal reaction $\vec{N}_A$ on (A), Weight $m_B\vec{g}$ de (B), normal reaction $\vec{N}_B$ on (B).	**0.5**
	1-2		$\Sigma\vec{F}_{ext} = \frac{d\vec{P}}{dt}$, then $m_A\vec{g} + \vec{N}_A + m_B\vec{g} + \vec{N}_B = \vec{0} = \frac{d\vec{P}}{dt}$, The linear momentum of the system (A, B, spring) is conserved.	**0.75**
	3	1	$\vec{P}_{initial} = \vec{P}_{final}$, then $\vec{0} = \vec{P}_A + \vec{P}_B$, $\vec{P}_A = -\vec{P}_B$ $\vec{P}_A = - m_B \vec{V}_B = - 0.8 \times 0.75\,\vec{\imath} = - 0.6\,\vec{\imath}$ (kg.m/s)	**1**
		2	$\vec{P}_A = m_A \vec{V}_A$, $\vec{V}_A = -\frac{0.6}{m_A}\vec{\imath}$ (m/s).	**0.5**
	4	1	Let F the maximum point reached by (A) $ME_1 = ME_2$, $\frac{1}{2} m_A V_A^2 + m_A g h_A = \frac{1}{2} m_A V_F^2 + m_A g h_{max}$ $\frac{1}{2} m_A V_A^2 = m_A g h_{max}$, $V_A = \sqrt{2 \times g \times h_{max}} = \sqrt{2 \times 10 \times 0.05} = 1$ m/s	**1.25**
		2	$V_A = \frac{0.6}{m_A} = 1$, then $m_A = 0.6$ kg.	**0.5**
2	2-1		Graphically $V_{max} = 1$m/s $KE_{max} = ½\, m_B V_{max}^2 = 0.4$ J	**0.75**
	2-2		The mechanical energy of the system is conserved: $PE_{max} = KE_{max} = 0.4$ J	**0.5**
	2-3		$X_{max} = 10$ cm	**0.5**
	2-4		$½\, k X_{max}^2 = 0.4$ then $k = 80$ N/m	**0.75**