وزارة التربية والتعليم العالي المديرية العامة للتربية دائرة الامتحانات	امتحانات الشهادة الثانوية العامة الفرع : علوم الحياة	الدورة العادية للعام ٢٠٠٨
	مسابقة في مادة الفيزياء المدة ساعتان	الاسم: الرقم:

<u>This exam is formed of three exercises in four pages.</u>
<u>The use of non-programmable calculators is recommended.</u>

First exercise (7 points) Horizontal oscillator

Consider a mechanical oscillator that is formed of a spring (R) of stiffness k and a body (C), of mass m and of center of mass G.

A- Determination of k and m.

In order to determine the values of m and k of this oscillator, we place it on a horizontal air table. The table functioning normally, we shift (C) from its equilibrium position and we then release it from rest at the instant $t_0 = 0$. (C) may move then without friction on the table, G moving along a horizontal axis. The origin O of this axis is the position of G when (C) is at equilibrium.

x and v are respectively the abscissa and the algebraic measure of the velocity of G at the instant t.

Convenient equipments allow us to record the variations of x and v and on of the energies of the oscillator as a function of time. These variations are represented in the graphs of the figures1, 2 and 3. The horizontal plane containing G is taken as a gravitational potential energy reference Take: $\pi^2 = 10$.

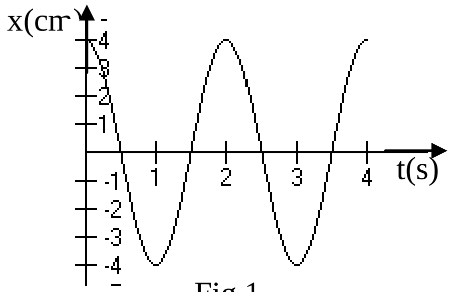


Fig.1

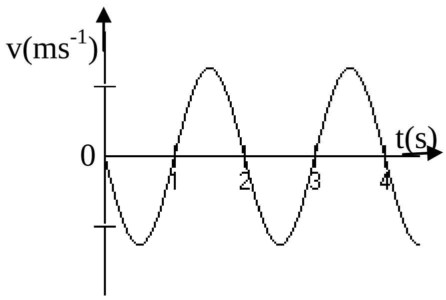


Fig.2

1) Referring to the graphs 1 and 2, determine:

a) The mode of the oscillations;

b) The initial values x_0 and v_0 of the motion;

c) The value of the proper period T_0 of the motion.

2) a) The figure 3 shows the variations of an energy E of the oscillator as a function of time. What form of energy is it? Justify.

b) The energy E is one of two terms of the mechanical energy M.E of the system (body, spring). Redraw figure 3 and show on it the shape of the variations of the mechanical energy M.E and that of the other form of that energy.

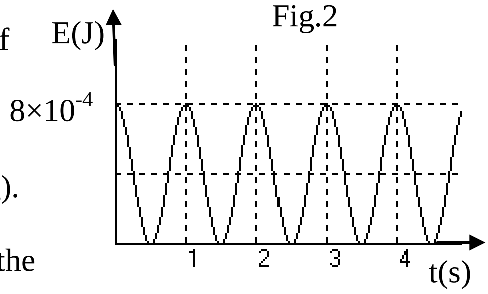


Fig.3

3) Deduce the values of m and k.

B- Driving the oscillations

The air table does not function normally any more and the forces of friction can no longer be neglected. We repeat the experiment under the same initial conditions. The variations of x, as a function of time, are recorded by an apparatus thus giving the graph of figure 4.

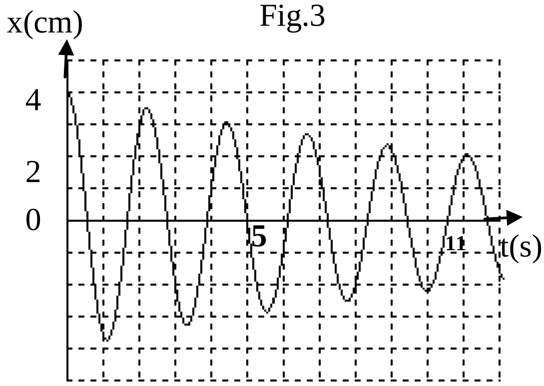


Fig.4

1) Specify the mode of oscillations performed by the oscillator.
2) Determine the value of the variation of the mechanical energy of the oscillator between the Instants: $t_0 = 0$ and $t = 11$ s.
3) A convenient apparatus allows us to drive these oscillations.
   a) What does the term « driving » the oscillations represent?
   b) Deduce the value of the average power of this apparatus between 0 and 11s.

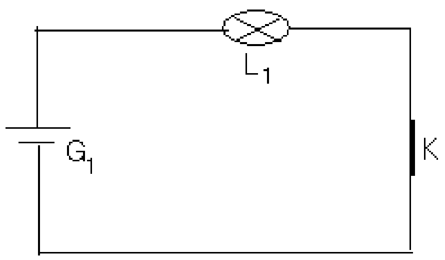
Second exercise (7 points) Role of a capacitor in a circuit

The object of this exercise is to study the role of a capacitor in an electric circuit in two different cases.($g = 10 m/s^2$)

A- Variation of the current in a circuit

***1*- Qualitative study**

We connect the two circuits whose diagrams are represented in the diagram below; the two identical lamps L_1 and L_2 are fed respectively with two identical generators G_1 and G_2 each of constant voltage E , the component (D) being a capacitor that is initially uncharged (Fig.1).



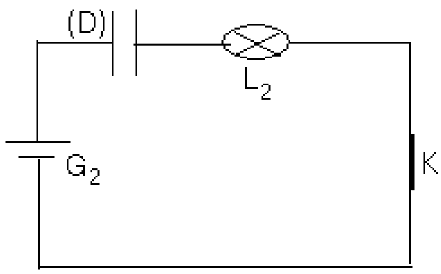


Figure 1

We close the two switches simultaneously at the instant $t_0 = 0$. We notice initially that L_1 and L_2 glow with the same brightness, but the brightness of the lamp L_2 decreases progressively and finally its light goes out, L_1 keeping its same brightness.

a) What can we say about the voltage across each of the lamps at the instant $t_0 = 0$? Justify.

b) i) How does the voltage across L_2 vary starting from the instant $t_0 = 0$?

ii) Deduce, when the light of L_2 goes out, the value of the voltage across the capacitor.

***2*- Quantitative study**

We connect a series circuit formed of a resistor of resistance R, a capacitor of capacitance C and a switch K across an ideal generator of e.m.f. E . At the instant $t_0 = 0$, the capacitor being uncharged, we close the switch K (Fig.2).

At the instant t, the charge of the armature B of the capacitor is q and the current carried by the circuit is i.

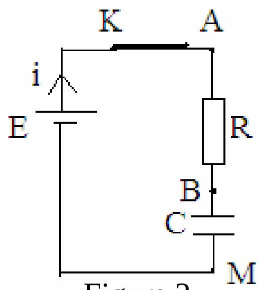


Figure 2

a. Write the relation between i and $\frac{dq}{dt}$.

b. Derive the differential equation in $u_{BM} = u_C$.

c. This differential equation has as solution: $u_C = E(1 - e^{-\frac{t}{\tau}})$

i) Determine the expression of τ in terms of R and C.

ii) Determine the expression of the current i in the circuit as a function of time.

iii) Draw the shape of each curve representing the variations of u_C and of i as a function of time.

***3*-**Deduce the role of the capacitor in the variation of the current in an RC circuit fed by a DC voltage during the charging phase.

***B*- Energy stored in a capacitor**

1- Qualitative study

Consider the experiment whose diagram is represented in figure (3), where (M) is a motor to which an body of mass m is suspended, a capacitor of large capacitance, G an ideal generator of constant voltage E, and K_1 and K_2 are two switches.

In the first step of the experiment, we open K_2, and we close K_1.

In the second step of the experiment, we open K_1 and we close K_2. We observe that the body rises.

Explain what happens in each step of the experiment. a tell why the body rises

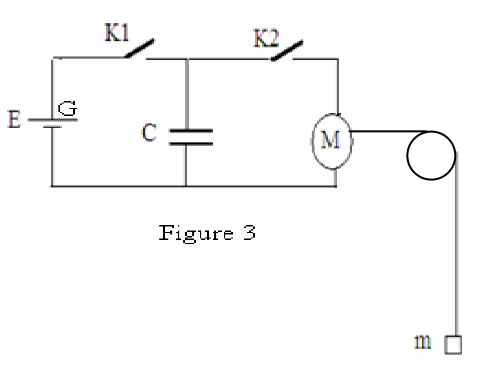


Figure 3

2- Quantitative study

The capacitor has a capacitance C = 1 F , the body has a mass m = 500g and the e.m.f of the generator is E = 3 V.

a- Calculate the energy initially stored in the capacitor.

b- Calculate the height rised by the body neglecting all energy losses.

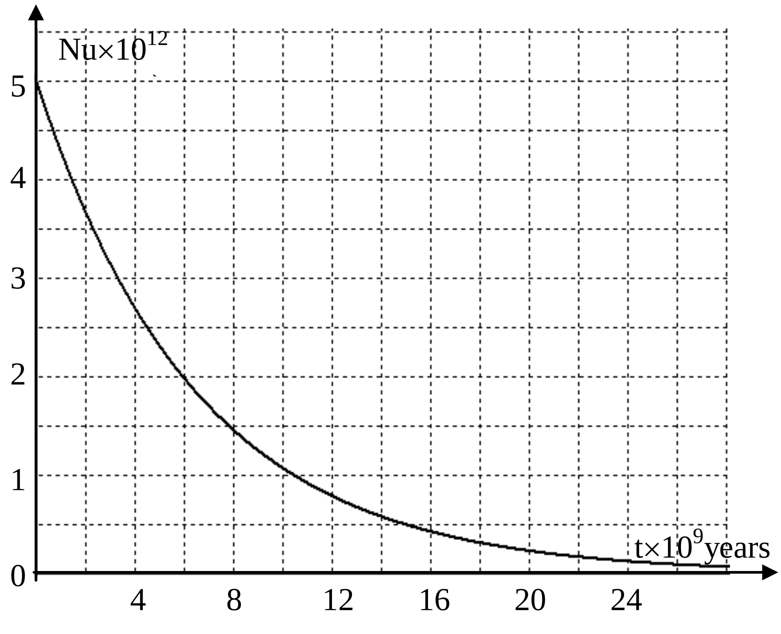
c- What type of energy transfer did take place?

d- In fact, the body rises 83 cm. Why?

e- Deduce the role of the capacitor in the previous circuit.

Third exercise (6 points) Determination of the age of the Earth

The object of this exercise is to determine the age of the Earth using the disintegration of a uranium 238 nucleus $\left({}^{238}_{92}U\right)$ into a lead 206 nucleus $\left({}^{206}_{82}\text{Pb}\right)$.



When we determine the number of lead 206 nuclei in a sample taken out from a rock that did not contain lead when it was formed, we can then determine its age that is the same as that of the Earth. The above figure represents the curve of the variation of the number N_u of uranium 238 nuclei as a function of time.

1 division on the axis of ordinates corresponds to 10^{12} nuclei.
1 division on the axis of abscissa corresponds to 10^{9} years.
The equation of the disintegration of Uranium 238 into lead 206 is:

$${}^{238}_{92}U \rightarrow {}^{206}_{82}Pb + x\beta^- + y\alpha$$

1 .Determine, specifying the laws used, the values of x and y.

2. Referring to the curve, indicate the number N_{0u} of uranium 238 nuclei existing in the sample at the date of its birth $t_o = 0$.

3. Referring to the curve , determine the period (half-life) of uranium 238.Deduce the value of the radioactive constant λ of uranium 238.

4. a) Give, in terms of N_{0u}, λ and t, the expression of the number N_u of uranium 238 nuclei remaining in the sample at instant t.

b) Calculate the number of uranium 238 nuclei remaining in the sample at instant $t_{1=}\ 2 \times 10^9$ years:

c) Verify this result graphically:

5. The number of lead 206 nuclei existing in the sample at the instant of measurement (age of the Earth) is $N_{pb} = 2.5 \times 10^{12}$ nuclei.

a) Give the relation among N_u, N_{0u} and N_{pb}.

b) Calculate the number N_u of uranium nuclei remaining in the sample at the date of measurement.

c) Determine the age of the Earth.

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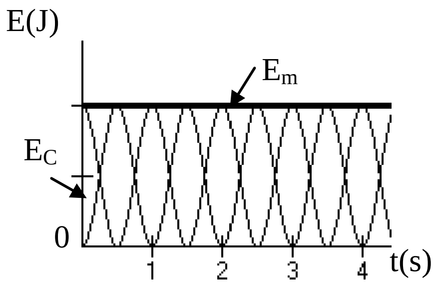
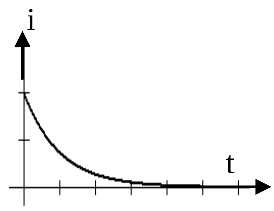
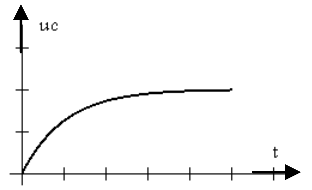
مشروع معيار التصحيح	مسابقة في مادة الفيزياء المدة ساعتان	الاسم: الرقم:

Part of the Q	Answer	Mark
	First exercise (7 points)	
A.1.a	Mode: free non-damped oscillations	0.50
A.1.b	At t = 0 we have: $x = x_0 = 4$ cm and $v = v_0 = 0$.	0.50
A.1.c	$T_0 = 2$ s	0.50
A.2.a	Elastic potential energy. Since at t = 0 $x = X_m$. And the value of that energy is maximum.	0.50
A.2.b	The curves are represented in the adjacent figure.  	1.25
A.3	$\frac{1}{2}kX_m^2 = 8\times10^{-4} \Rightarrow k = 1$ N/m. $T_0 = 2\pi\sqrt{\frac{m}{k}} \Rightarrow m = \frac{kT_0^2}{4\pi^2} \Rightarrow m = 0.1$ kg	1.50
B.1	Mode: Free and damped oscillations	0.50
B.2	$\Delta M.E = \frac{1}{2}kX_{m(t)}^2 - \frac{1}{2}kX_{m(0)}^2 = -6\times10^{-4}$ J.	0.75
B.3.a	Provides energy to compensate for the loss during the oscillations.	0.25
B.3.b	$P_{av} = \frac{\lvert\Delta M.E\rvert}{\Delta t} = 5.45\times10^{-5}$ W.	0.75
	Second exercise (7 points)	
A.1.a	the two voltages are equal because the lamps glow with the same brightness.	0.25
A.1.b.i	u_2 decreases, in fact $E = u_2 + u_C$ = cte but u_C increase thus u_2 decreases.	0.50
A.1.b.ii	- When the light of L_2 goes out $u_2=0 \Rightarrow E = u_C + u_2 = u_C \Rightarrow$ we can then find the voltage of the generator G_2 across the capacitor.	0.50
A.2.a	$i = \frac{dq}{dt}$	0.25
A.2.b	$E = Ri + u_C$, but $i = \frac{dq}{dt} = C\frac{du_C}{dt} \Rightarrow E = RC\frac{du_C}{dt} + u_C$.	0.75
A.2.c.i	$C\frac{du_C}{dt} = C\times\frac{E}{\tau}e^{-\frac{t}{\tau}} \Rightarrow E = R\times C\times\frac{E}{\tau}e^{-\frac{t}{\tau}} + E(1 - e^{-\frac{t}{\tau}})$ $\Rightarrow \frac{RC}{\tau} - 1 = 0 \Rightarrow \tau = RC$.	0.75

A.2.c.ii	$i = C\frac{du_C}{dt} = C \times \frac{E}{\tau}e^{-\frac{t}{\tau}} = \frac{E}{R}e^{-\frac{t}{\tau}}$.	0.50
A.2.c.iii	 	0.50
A.2.c.iv	The capacitor does not allow the passage of the current except during a short time when the circuit is fed by a DC voltage.	0.50
B.1	In the first step, the capacitor is charged till it reaches a voltage u_C= E. In the second step, the capacitor is discharged in the motor by providing across the motor a voltage u_C which decreases from the value E, thus it allows the lifting of the body.	0.50
B.2.a	W = 1/2 CE^2 = 1/2 (1)(9)= 4.5 J.	0.50
B.2.b	$W = mgh_{max} \Rightarrow h_{max} = \frac{4.5}{0.5\times 10} = 0.9\,m$.	0.75
B.2.c	The electric energy stored in the capacitor is transformed into mechanical energy.	0.25
B.2.d	Because of friction	0.25
B.2.e	The capacitor stores electric energy and restitute this energy when needed.	0.25
	Third exercise (6 points)	
1	${}^{238}_{92}U \rightarrow {}^{206}_{82}Pb + x\,{}^{0}_{-1}e + y\,{}^{4}_{2}He$ The laws of conservation of the mass number and the charge number give 238 = 206 + 4y $\Rightarrow$ y = 8 α decays. 92 = 82 – x + 2y $\Rightarrow$ x = 6 β^- decays.	1.25
2	$N_{0ou} = 5 \times 10^{12}$ nuclei	0.50
3	For the half-life $N_u = \frac{N_{OU}}{2} = 2.5\times 10^{12}$ nuclei. On the graph we find T $\approx 4.5\times 10^{9}$ years. The radioactive constant $\lambda = \frac{0.693}{T} = \frac{0.693}{4.5\times 10^{9}} = 1.54\times 10^{-10}$ year $^{-1}$	1.50
4.a	$N_u = N_{ou}\, e^{-\lambda t}$	0.25
4.b	$N_u = 5 \times 10^{12}\ e^{-1.54\times 10^{-10}\times 2\times 10^{9}} = 3.675 \times 10^{12}$ nuclei.	0.75
4.c	On the graph: 2 × 10^9 years corresponds 3.7 × 10^{12} nuclei	0.50
5.a	$N_{ou} = N_u + N_{Pb}$	0.25
5.b	a. $N_u = N_{ou} - N_{Pb} = 5 \times 10^{12} - 2.5 \times 10^{12} = 2.5 \times 10^{12}$ nuclei.	0.50
5.c	$N_u = \frac{N_{OU}}{2}$; the age of the Earth is equal to the half-life of uranium 238. this age is 4.5 ×10^9 years.	0.50