دورة سنة ٢٠٠٥ العادية	امتحانات الشهادة الثانوية العامة فرع علوم الحياة	وزارة التربية والتعليم العالي المديرية العامة للتربية دائرة الامتحانات
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This exam is formed of three obligatory exercises in three pages numbered from 1 to 3.

The use of non-programmable calculators is allowed.

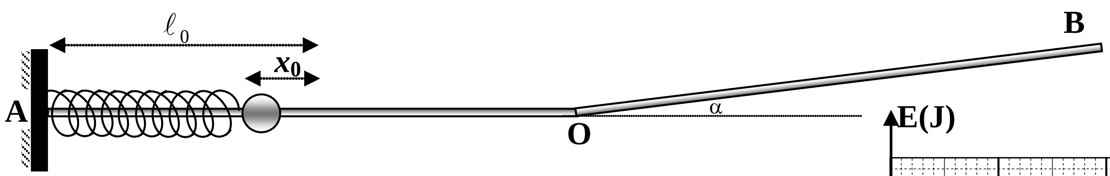
<u>First Exercise</u> (6 ½ pts) <u>Determination of the value of a force of friction</u>

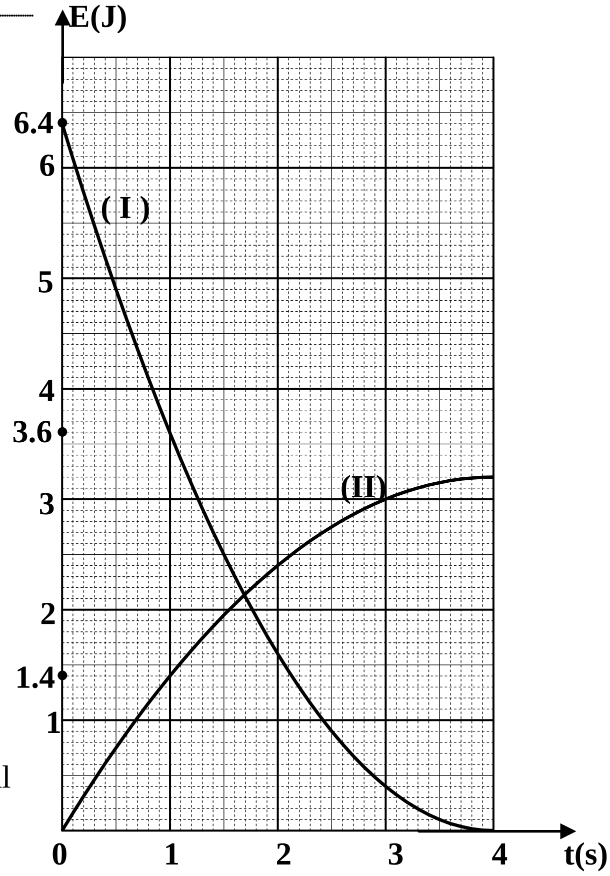
A solid (S) of mass m = 200 g is free to move on a track AOB lying in a vertical plane. This rail is formed of two parts: the first one AO is straight and horizontal and the other OB is straight and inclined by an angle α with respect to the horizontal (sin α = 0.1). Along the part AO, (S) moves without friction, and along the part OB, (S) is acted upon by a force of friction $\vec{f}$ that is assumed constant and parallel to the path.

The object of this exercise is to determine the magnitude f of the force $\vec{f}$ of friction.

A- Launching the solid

In order to launch this solid on the part AO, we use a spring of constant k = 320 N / m and of free length ℓ_0 ; one end of the spring is fixed at A to a support. We compress the spring by x_o; we place the solid next to the free end of the spring and then we release them. When the spring attains its free length ℓ_0, the solid leaves the spring with the speed V_0 = 8 m/s; it thus slides along the horizontal part and then rises up at O the inclined part OB.





1) Determine the value of x_o.

2) The solid reaches O with the speed V_0 = 8 m/s. Justify.

B- Motion of the solid along the inclined part OB

(S) moves, at O, up the inclined part OB with the speed V_0 at the instant t_o= 0. A convenient apparatus is used to trace, as a function of time, the curves representing the variations of the kinetic energy K.E of the solid and the gravitational potential energy $P.E_g$ of the system (solid - Earth). These curves are represented in the adjacent figure between the instants t_o= 0 and t_4 = 4 s, according to the scale:

- 1 division on the time axis corresponds to 1 s
- 1 division on the energy axis corresponds to 1 J.

The horizontal plane through point O is taken as a gravitational potential energy reference. Take g = 10 m / s^2.

1) The curve **(I)** represents the variation of the kinetic energy K.E of (S) as a function of time. Why?

2) Using the curves:

a) specify the form of the energy of the system at the instant $t_4 = 4$ s. Justify your answer.

b) determine the maximum distance covered by the solid along the part OB.

c)i) complete the table with the values of the mechanical energy M.E of the system at each instant t.

t (s)	0	1	2	3	4
M.E (J)		5			

ii) justify the existence of a force of friction $\vec{f}$.

iii) calculate the variation in the mechanical energy of the system between the instants $t_o = 0$ and $t_4 = 4$ s.

iv) determine f .

<u>Second Exercise</u> (7pts) <u>Determination of the inductance of a coil</u>

In order to determine the inductance L of a coil of negligible resistance, we put this coil with a resistor of resistance R = 10 Ω and a capacitor of capacitance $C = \frac{160}{\sqrt{3}}$ μF all in series across a generator G of adjustable frequency delivering an alternating sinusoidal voltage $u_{AM} = U_m \sin(2\pi f t)$ (figure 1). The circuit thus carries an alternating sinusoidal current i.

An oscilloscope is connected so as to display the voltage u_{AM} on the channel Y_1 and the voltage u_{DM} on the channel Y_2.

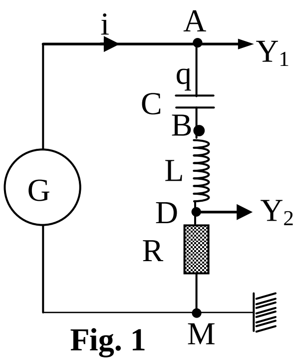


Fig. 1

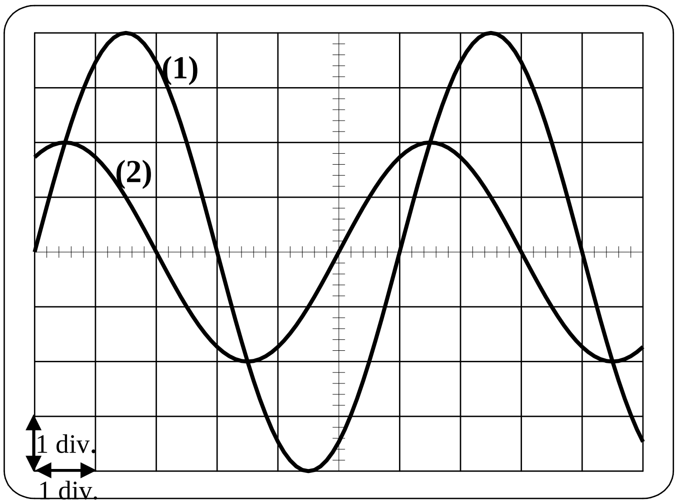


Fig. 2

A) The frequency of u_{AM} is adjusted at f = 50 Hz.

The waveforms of figure 2 show the curve (1) corresponding to the voltage u_{AM} and the curve (2) that corresponds to the voltage u_{DM}. The vertical sensitivity on both channels is 5 V / division.

Given: $\sqrt{3} = 1.73$ $0.32\,\pi = 1$

1) Referring to the waveforms:

a) calculate the maximum voltage U_m across the generator.

b) show that the expression of the voltage u_{DM} may be written in the form:

$$u_{DM} = 10 \sin(100\pi t + \frac{\pi}{3}) \quad (u_{DM} \text{ in V, t in s}).$$

2) a) Determine the expression of i.

b) Show that the expression of the voltage across the terminals of the capacitor can be written as:

$$u_C = u_{AB} = -20\sqrt{3}\cos(100\pi t + \frac{\pi}{3})$$

c) Determine the expression of the voltage u_{BD} across the coil in terms of the inductance L and time t.

3) The relation $u_{AM} = u_{AB} + u_{BD} + u_{DM}$ is valid at any instant t. Deduce the value of L.

B) In order to verify the value of L obtained in part **A-*3***, we vary the frequency f of the voltage delivered by G, keeping the same value of the maximum voltage U_m. We notice that the two voltages u_{AM} and u_{DM} become in phase when the value of the frequency is $f_0 = 70.7$ Hz.

1) Give the name of the electric phenomenon that takes place.

2) Determine again the value of L.

<u>Third Exercise</u> (6 ½ pts) <u>Radioactivity</u>

A physics laboratory is equipped with a radioactivity counter together with a source of radioactive cesium $^{137}_{55}Cs$ which is a β^- emitter.

The technical data sheet of the counter carries the following indications:

- *nuclide :* $^{137}_{55}Cs$
- *half-life : T = 30 years*
- *activity of the source at the date of fabrication of the counter :* $A_0 = 4.40 \times 10^5$ *Bq*
- *energy of beta radiation : 0.514 MeV*
- *energy of gamma radiation : 0.557 MeV*

Take : 1 eV = 1.6×10^{-19} J. 1 u = 931.5 MeV / c^2

Masses of nuclei and particles: m (Cs) = 136.8773 u ; m (Ba) = 136.8756 u ; m (electron) = 5.5×10^{-4} u

A- Energy liberated by a cesium nucleus

1- a) Write the equation of the decay of cesium 137, knowing that the daughter nucleus is $^{y}_{x}Ba$. Determine x and y.

b) The barium $^{y}_{x}Ba$ obtained is in an excited state. Write the equation of the downward transition of the barium nucleus.

2-a) Calculate, in MeV, the energy E liberated during the disintegration of a cesium nucleus.

b) Starting from the technical data sheet, deduce the energy carried by the antineutrino neglecting the kinetic energy of the barium nucleus.

B- Activity of cesium

1. At the beginning of the school year 2004, we measure, using the counter, the activity A of the source. We obtain the value 3.33×10^5 Bq. Determine the year of fabrication of the counter equipped with its source knowing that $A = A_0 . e^{-\lambda t}$, λ being the radioactive constant of cesium.

2. The activity of the source remains practically the same within one hour. Starting from the definition of the activity of a radioactive source, deduce the number n of disintegrations that cesium undergoes within one hour.

C- Consequences of using the cesium source

1. Having calculated the values of E and n, calculate, in J, the energy received by a student within one hour of experimental work in the laboratory knowing that the student absorbs 1% of the liberated nuclear energy.

2. Knowing that the maximum nuclear energy that a student may absorb within one hour without any risk is 1.2×10^{-4} J, verify that student is not subject to any danger.

أسس التصحيح لشهادة علوم الحياة المادة: فيزياء دورة ٢٠٠٥ العادية

First Exercise

A- 1) Explanation **(1/2pt) ;** $\frac{1}{2}k(x_o)^2 = \frac{1}{2}m(V_0)^2$……….. **(1/2 pt)**

x_0 = 20 cm ……………………………………………**(1/2 pt)**

2) The method of conservation of M.E or $\Sigma\vec{F} = \vec{P}+\vec{N}=\vec{0}$, the motion is thus URM with a speed same as V_0 = 8 m/s . … **(1/2pt)**

B- 1) At the instant t= 0, the speed of the solid is 8m/s, its K.E is maximum. The curve **I** passes through a maximum then. **(1/2pt)**

2) a) At the instant t = 4 s, K.E = 0 , The energy of the system then is gravitational potential . …………………… …**(1/2pt)**

b) The maximum distance corresponds to the maximum value of the gravitational P.E on the curve II ;

$P.E_{gmax}$= 3.2 J = mgh_{max} = mg $d_{max}\sin\alpha$, thus : d_{max}= 16 m **(1pt).**

t (s)	0	1	2	3	4
M.E (J)	6.4	5	4	3.4	3.2

c) i. Table ……………………………………………………. **(1pt)**

ii. The mechanical energy decreases with time ; this means that friction exists. **(1/4pt)**

iii. ΔM.E = 3.2 – 6.4 = - 3.2 J **(1/2pt)**

iv. ΔM.E = W($\vec{f}$) = - $f \times d_{max}$ **(1/2pt)**

$f = \frac{3.2}{16} = 0.2N$ **(1/2pt)**

Second Exercice

A- 1- a)U_m = 4 div $\times$ 5 V/div = 20 V **(1/2pt)**

b) U_{DMm} = 2 div $\times$ 5 V/div = 10V

The phase difference between u_{DM} and u_{AM} is

φ_1 = 1div $\times \frac{2\pi}{6} = \frac{\pi}{3}$ rad

u_{DM} leads u_{AM}.

u_{DM} = 10sin $(100\pi t + \frac{\pi}{3})$ **(1 ½ pt)**

2) a) u_{DM} = Ri => i = $\sin(100\pi t + \frac{\pi}{3})$ **(1/2pt)**

b) i = $C\frac{du_C}{dt}$ **(1/4pt)** => u_C = primitive de $\frac{1}{C}$ i **(1/4pt)**

= - $20\sqrt{3}\cos(100\pi t + \frac{\pi}{3})$ **(1/4pt)**

(1pt)

c) $u_{BD} = L\frac{di}{dt}$ **(1/4pt)**

= $100\pi L\cos(100\pi t + \frac{\pi}{3})$ **(1/2pt)**

3) The relation $u_{AM} = u_{AB} + u_{BD} + u_{DM}$ can be written as :

$20\sin 100\pi t = -20\sqrt{3}\cos(100\pi t + \frac{\pi}{3}) + 100\pi L\cos(100\pi t + \frac{\pi}{3})$

$+ 10\sin(100\pi t + \frac{\pi}{3})$ **(1/4pt)**

For t = 0, we get : $0 = -10\sqrt{3} + 50\pi L + 5\sqrt{3}$. thus : L = 55 mH.

(1 ¼ pt)

B- 1) The phenomenon is current resonance **(1/2pt)**

2) Resonance, implies

$f_0 = \frac{1}{2\pi\sqrt{LC}}$, thus : L $\approx$ 55 mH. **(1pt)**

Third Exercise

A- 1) a) $^{137}_{55}Cs \rightarrow\ ^{y}_{x}Ba +\ ^{0}_{-1}e +\ ^{0}_{0}\bar{\nu}$ **(1/2pt)**

$55 = x - 1 \Rightarrow x = 56$; $137 = y + 0 \Rightarrow y = 137$ **(1/2pt)**

b) $^{y}_{x}Ba^{*} \rightarrow\ ^{y}_{x}Ba + \gamma$ **(1/2pt)**

2) a) $E = \Delta m \times c^2$. with $\Delta m = m_{before} - m_{after} = m_{Cs} - (m_{Ba} + m_{elecron}) = 1.15 \times 10^{-3}$ u

$\Delta m = 1.15\times10^{-3} \times 931.5$ MeV/c^2 = 1.0712 MeV/c^2.

E = 1.0712 MeV/c$^2\times$ c^2 = 1.0712 MeV. **(1 ½ pt)**

b) E(liberated) = E(γ) + E(β^-) + K.E (Ba) + E($^{0}_{0}\bar{\nu}$)

1.0712 MeV = 0.557 + 0.514 + 0 + E ($^{0}_{0}\bar{\nu}$) => E ($^{0}_{0}\bar{\nu}$) = 0.0002 MeV. **(1pt)**

B) 1) $A = A_0 e^{-\lambda t}$, hence $t = \dfrac{1}{\lambda}\times\ln\dfrac{A_0}{A}$ =12 years.

Thus the date of fabrication of the counter is the beginning of the year 1992. **(1/2pt)**

2) Number of disintegrations during 1 h = n = A $\times$t = $3.33.10^5\times3600 = 11988\times10^5$

(1/2 pt)

C- 1) Energy liberated during 1 hour = E$_1$ = E $\times$ number of disintegrations during 1 hour

h = E $\times$ n = $1.0712\times11988\times10^5$ MeV = 12841.5×10^5 MeV = 0.2055×10^{-3}J.

Energy absorbed by the student during 1 h = $E_2 = \dfrac{0.2055\times10^{-3}}{100} = 0.2055\times10^{-5}$J **(1 pt)**

2) $E_2 < 1.2\times10^{-4}$J => not any risk **(1/2pt)**