وزارة التربية والتعليم العالي
المديريّـــة العامة للتربية
دائرة الامتحانات الرسمية

امتحانات الشهادة الثانوية العامة
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مكيّفة/ احتياجات خاصة

مسابقة في مادة الفيزياء

المدة: ساعتان

(اللغة الإنكليزية)

الاسم:.................................

الرقم:.................................

Exercise 1 (7 points)

Determination of the stiffness of a spring

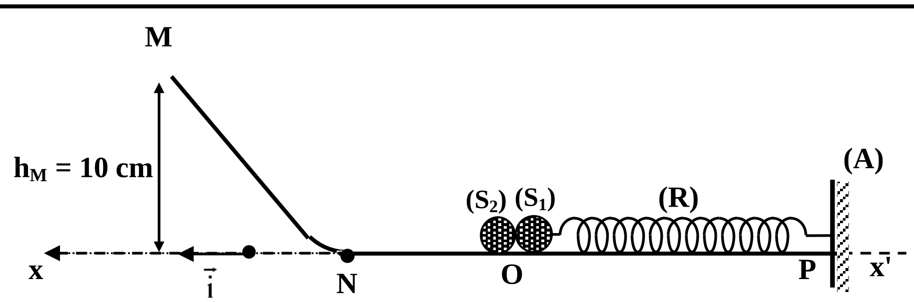
In order to determine the stiffness k of a massless spring (R), we consider:

- a track MNP found in a vertical plane ;
- a massless spring (R) of horizontal axis and stiffness k,
  - having one end fixed to a support (A);
  - the other end is connected to an object (S_1) considered as a particle of mass $m_1 = 0.2$ kg;
- an object (S_2) considered as a particle of mass $m_2 = 0.3$ kg.
  - (S_2) is placed at O of a horizontal x-axis of unit vector $\vec{i}$ (Doc. 1).

Neglect all the forces of friction.

Take:

- the horizontal plane passing through NP as a reference level for gravitational potential energy;
- $g = 10$ m/s^2.



Doc. 1

1- Collision between (S_1) and (S_2)

At equilibrium, (S_1) coincides with O.

(S_1) is shifted from O to the right by a certain distance and it is released from rest.

(S_1) reaches O with a velocity $\overrightarrow{V_1} = 2\,\vec{i}$ (m/s), and enters into a head-on collision with (S_2) initially at rest.

Just after collision, (S_1) rebounds with a velocity $\overrightarrow{V'_1} = -0.4\,\vec{i}$ (m/s).

(S_2) moves to the left with a velocity $\overrightarrow{V'_2} = V'_2\,\vec{i}$.

1-1) Applying the principle of conservation of linear momentum for the system $[(S_1), (S_2)]$, **show that** $V'_2 = 1.6$ m/s.

1-2) **Calculate the kinetic energy** of the system $[(S_1), (S_2)]$ just before collision.

Calculate the kinetic energy of the system $[(S_1), (S_2)]$ just after collision.

Deduce that this collision is elastic.

2- Motion of (S_2) after collision

Just after collision, (S_2) moves along the horizontal track PN with the speed V'_2 and then continues its motion along the inclined plane MN.

(S_2) leaves the inclined plane at M with a speed V_M.

The height of M above the reference level is $h_M = 10$ cm.

Show that the value of the speed is $V_M = 0.748$ m/s.

3- Oscillation of (S_1)

After collision, (S_1) oscillates along the x-axis.

At an instant t, the abscissa of (S_1) is x and the algebraic value of its velocity is $v = \frac{dx}{dt}$.

3-1) **Write**, at an instant t, the expression of the mechanical energy of the system $[(S_1)$, spring, Earth$]$ in terms of m_1, k, x and v.

3-2) **Show that** the second order differential equation in x that describes the motion of (S_1) is given by: $x'' + \frac{k}{m}x = 0$.

3-3) **Deduce** the expression of the proper period T_0.

3-4) **Calculate** k knowing that $T_0 = 0.314$ s.

<u>Exercise 2</u> **(6 points)**

Scintigraphy in medicine

The bones scintigraphy is a medical examination that permits to observe bones and articulations. The aim of this exercise is to study a radioactive sample used in this scintigraphy.

This medical examination uses technetium-99 produced due to the disintegration of molybdenum-99 according to the following nuclear reaction:

$$^{99}_{42}\text{Mo} \rightarrow {}^{99}_{43}\text{Tc} + {}^{A}_{Z}\text{X} + \gamma$$

The energy of the emitted gamma (γ) photon is 140 keV.

Given: $c = 3\times10^{8}$ m.s^{-1}; 1eV = 1.6×10^{-19} J;

Planck's constant $h = 6.6\times10^{-34}$ J.s.

1- **Identify** the <u>emitted particle</u> ${}^{A}_{Z}\text{X}$, **indicating** the <u>used laws</u>.

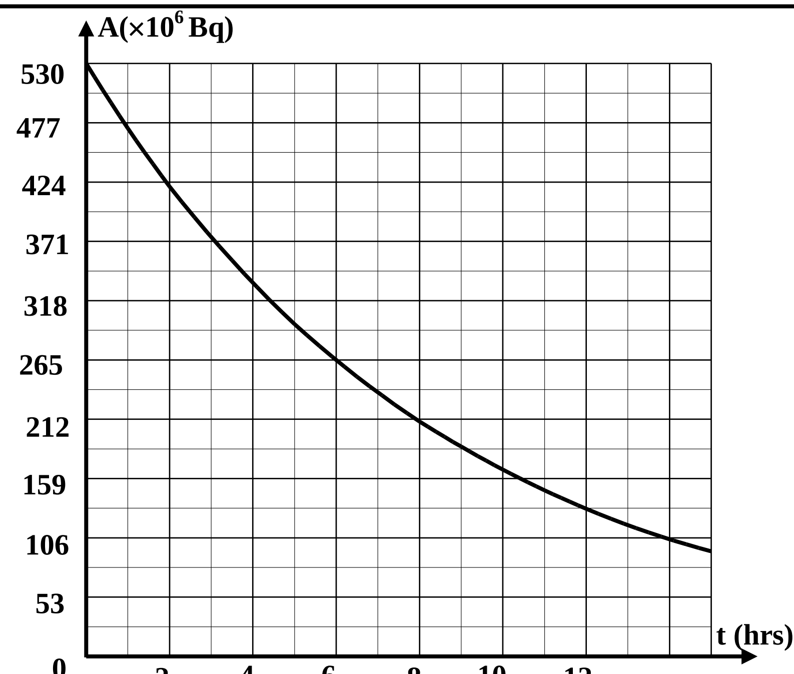
2- The emitted particle ${}^{A}_{Z}\text{X}$ is always accompanied with the emission of another particle. **Name** <u>this particle</u>.

3- **Indicate** <u>the cause of the emission of the gamma photon</u>.

4- **Calculate** <u>the wavelength of the emitted gamma photon</u>.

5- Technetium-99 is a radioactive substance.

The graph of document 2 represents the activity of a sample of technetium-99 as a function of time.



Doc. 2

Using document 2, **show that** the radioactive period (half-life) of technetium-99 is T = 6 hrs.

6- In a session of scintigraphy examination, a patient is injected at $t_0 = 0$ by techenetium-99 of activity $A_0 = 530 \times 10^6$ Bq.

At the end of the examination session, the activity of technetium in the body of the patient is 63% of its initial value.

6-1) **Write**, at instant t, the expression of the activity A in terms of A_0, t and the decay constant λ.

6-2) Using the preceded expression:

6-2-1) Show that the duration of the examination session is 4 hrs.

6-2-2) Determine the ratio $\frac{A}{A_0}$ of technetium-99 at t = 40 hrs.

<u>Exercise</u> 3 (7 points)

RLC series circuit in the radio

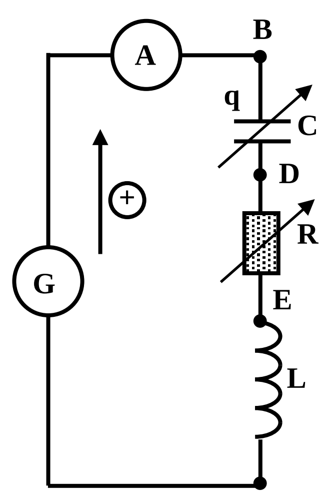
One of the useful applications of an RLC series circuit is used in radios.

This exercise studies the effect of the capacitance C on the detection of the radio wave and the effect of the resistance R on the loudness of the sound emitted by the radio.

1– Experimental study of an RLC series circuit

Document 3 represents an RLC series circuit formed of:

- a capacitor of adjustable capacitance C;
- a resistor of adjustable resistance R;
- a coil of inductance L = 0.317 H and negligible resistance;
- an ammeter (A) of negligible resistance.



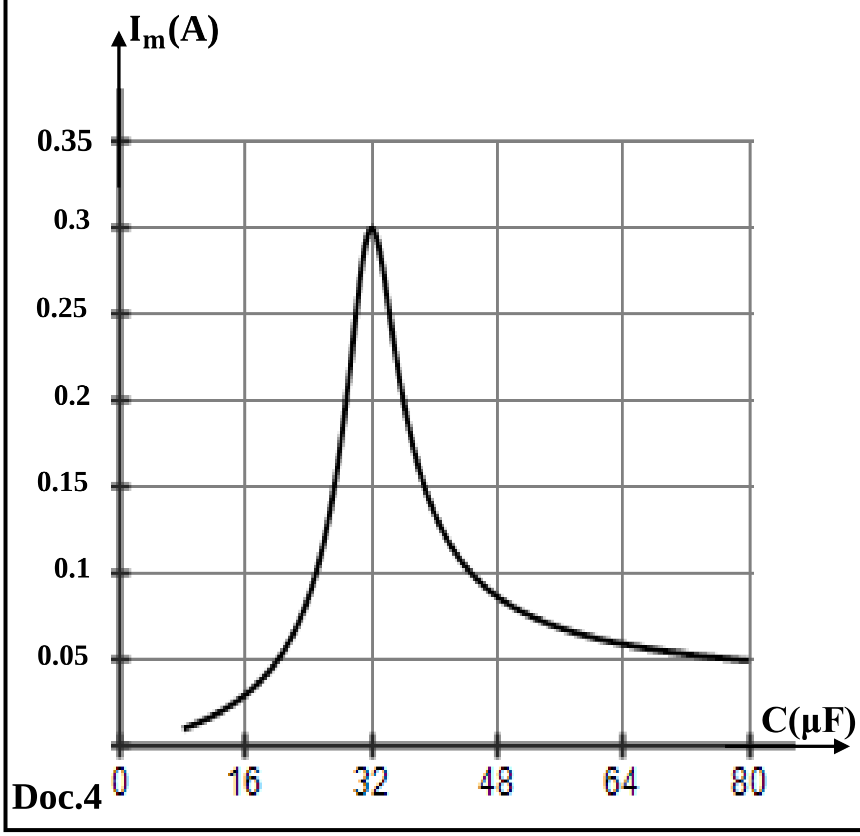
Doc. 3

This circuit is connected across a generator (G) maintains across its terminals an alternating sinusoidal voltage $\mathbf{u_G = u_{BF} = 3\sin(\omega t)}$, **($u_G$ in V, t in s) and ω = 314 rad/s.**

The expression of the current in the circuit is $\mathbf{i = I_m \sin(\omega t + \varphi)}$.

For each value of C, the ammeter permits to obtain the amplitude I_m of the current i.

The graph of document 4 represents I_m as a function of C.



Doc.4

1-1) Indicate the value C_0 of C at which I_m attains a maximum value.

1-2) Calculate the value of $LC_0\omega^2$.

1-3) Name then the electric phenomenon observed on document 4.

1-4) The capacitance of the capacitor is C = 32 µF.

1-4-1) Pick out graphically the value of I_m.

1-4-2) Show that the expression of the current is given by:

$i = 0.3 \sin(314\,t)$, (i in A, t in s).

1-4-3) Determine the expression of the voltage $u_L = u_{EF}$ across the terminals of the coil as a function of time **t**.

1-4-4) Determine the expression of the voltage $u_C = u_{BD}$ across the terminals of the capacitor as a function of time **t** knowing that $\mathbf{i = C \dfrac{du_c}{dt}}$

1-4-5) Show that u_R □ $u_G = 3 \sin(314t)$, **using** the law of addition of voltages $u_G = u_C + u_L + u_R$ (knowing that $u_R = u_{DE}$ is the voltage across the resistor).

1-4-6) Deduce the value of R knowing that $\mathbf{U_m = R\, I_m}$.

1-4-7) We decrease the value of R to 2 Ω. **Calculate** the new value of the maximum current in the circuit using the relation $u_R = u_G$.

2 - RLC series circuit in the radio

Each radio station broadcasts an electromagnetic wave (radio wave) of precise frequency f.

When this radio wave of frequency f is received by the antenna of a radio, it is converted into electric sinusoidal signal of same frequency f; thus the antenna plays the role of a generator and feeds the RLC series circuit in the radio.

Given:

- the inductance of an RLC series circuit in a radio is L = 0.2 mH;
- the values of R and C can be adjusted;
- when the circuit enters an electric phenomenon similar to that of part (1-3) the antenna receives the desired frequency of the wave of the broadcast ($LC_0\omega^2 = 1$) .

2-1) **Determine** the value of C so that the antenna receives a radio wave of desired frequency 1000 kHz.

2-2) To increase the intensity of the emitted sound by the radio we have to increase the value of the current in the circuit. **Indicate** whether we have to increase or decrease the resistance R in order to increase the intensity of the emitted sound by the radio.