المملكة المغربية
وزارة التربية الوطنية
والتكوين المهني
والتعليم العالي والبحث العلمي

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المركز الوطني للتقويم والإمتحانات والتوجيه

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة الاستدراكية 2018
-الموضوع-

RS30E

المادة	الفيزياء والكيمياء	مدة الإنجاز	4
الشعبة أو المسلك	شعبة العلوم الرياضية : " أ" و " ب" – خيار أنجليزية	المعامل	7

The use of the non-programmable scientific calculator is allowed.

This exam paper consists of four exercises; one in Chemistry and three in Physics.

<u>Chemistry (7 points)</u>

- Volumetric rate of a reaction; acid-base reactions
- Accumulator Silver-Iron

<u>Physics (13 points)</u>

❖ **Waves (2,25 points):**

- Ultrasonic waves.

❖ **Electricity (5,25 points):**

- RC dipole and LC circuit,
- Amplitude Modulation.

❖ **Mechanics (5,5 points)**

- Motion of a skier,
- Motion of a simple pendulum.

Chemistry (7 points) **Part I and Part II are independent.**

Part I: Volumetric rate of a reaction; acid-base reactions

Chloride bleach is a chemical product of current use. It is a disinfectant and very effective against the bacterial and viral contaminations.

The active principle of the chloride bleach is due to the presence of the hypochlorite ion ClO^-. This ion is able to act as either an oxidant and a base.

In this part of the exercise we study:

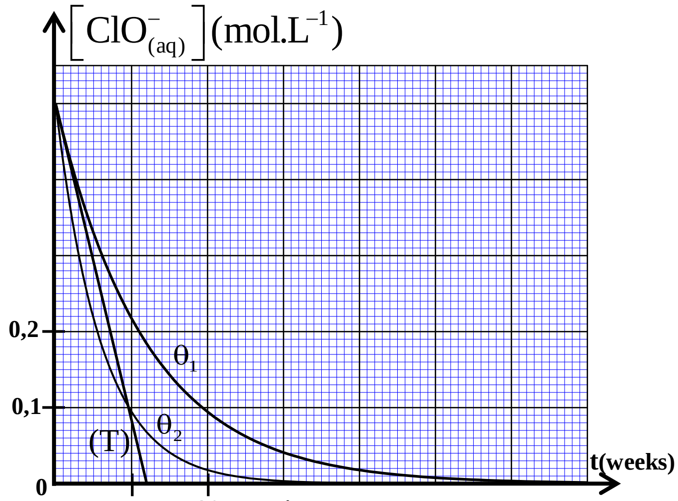
- The kinetics of the decomposition of hypochlorite ions ClO^-;
- Acid –base reactions using the pair $HClO_{(aq)}/ClO^-_{(aq)}$.

1- Temporal Monitoring of the effective molar concentration of the hypochlorite ion ClO^-

During the storing of the chloride bleach, hypochlorite ions ClO^- contained in the bleach decomposes according to the chemical equation of reaction below:

$$2ClO^-_{(aq)} \longrightarrow 2Cl^-_{(aq)} + O_{2(g)}.$$

Under determined experimental conditions, we obtain the curves shown in figure 1, which represent the evolution of $\left[ClO^-_{(aq)}\right]=f(t)$ at two different temperatures θ_1 and θ_2.



10 20 Figure 1

0,5 **1-1-** Draw the progress table (we denote the volume of the solution studied V assumed to be constant, and $C_0=\left[ClO^-_{(aq)}\right]_0$ the molar concentration of ClO^- at $t=0$).

0,75 **1-2-** Show that the molar concentration of the hypochlorite ion at half-life of a reaction $t=t_{1/2}$ is $\dfrac{C_0}{2}$. Deduce graphically $t_{1/2}$ of the experience performed at the temperature θ_2.

0,5 **1-3-** Find out, at the temperature θ_1, the volumetric rate of the reaction at the instant t=0 in $mol.L^{-1}.week^{-1}$ ((T) represents the tangent of the curve at the instant t=0).

0,25 **1-4-** Compare θ_1 and θ_2. Justify your answer.

2- Study of some aqueous solutions which involve the pair $HClO_{(aq)}/ClO^-_{(aq)}$

Given: - All measurements are performed at 25^0C;

- The ionic product of water: $K_e=10^{-14}$;

- The acid dissociation constant of the pair $HClO_{(aq)}/ClO^-_{(aq)}$ is $K_A=5.10^{-8}$;

The measurement of the pH of an aqueous solution (S) of the hypochlorous acid $HClO$ of molar concentration C and of volume V, gives $pH=5,5$.

0,5 **2-1-** Write the chemical equation of the reaction between the hypochlorite acid $HClO$ and water.

0,75 **2-2-** Find out the expression of the molar concentration C in terms of pH and K_A. Calculate its value.

0,5 **2-3-** We define the ratio of the base specie ClO^- in a solution by : $\alpha(ClO^-)=\dfrac{[ClO^-]_{éq}}{[ClO^-]_{éq}+[HClO]_{éq}}$.

Show that $\alpha(ClO^-)=\dfrac{K_A}{K_A+10^{-pH}}$.

2-4- The curve in figure 2 represents the variations of the ratio of one specie among acid or base of the pair $HClO_{(aq)}/ClO^-_{(aq)}$ (expressed in percentage) as a function of pH.

0,25 **2-4-1-** What is the chemical specie of the pair $HClO_{(aq)}/ClO^-_{(aq)}$ for which the curve is associated?

0,5 **2-4-2-** Using the graph in figure 2, identify the predominant chemical specie of the pair $HClO_{(aq)}/ClO^-_{(aq)}$ in the solution (S).

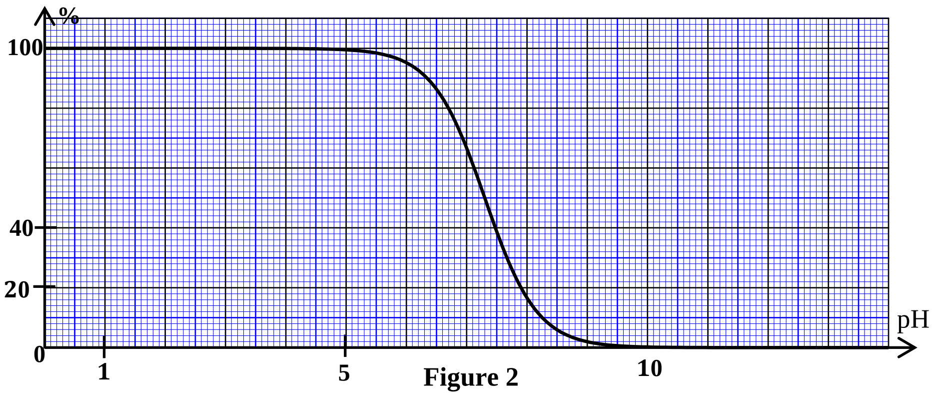


Figure 2

2-5- We mix a volume V_a of an aqueous solution of the hypochlorous acid of molar concentration C_a with a volume V_b of an aqueous solution of sodium hydroxide $Na^+_{(aq)}+HO^-_{(aq)}$ of molar concentration $C_b=C_a$. The pH of the solution obtained is $pH=7,3$.

0,5 **2-5-1-** Determine the value of the equilibrium constant K associated with the equation of the reaction produced.

0,5 **2-5-2** – Based on the graph shown in figure 2, calculate the ratio $\dfrac{[HClO]_{éq}}{[ClO^-]_{éq}}$. What is the deduction?

Part II: Accumulator Silver-Iron

Accumulators are energy converters. Unlike batteries whose reactants are consumed in an irreversible reaction during the functioning, the reactants in the accumulator can be regenerated by a charging process.

In this exercise we will study, the discharging of the accumulator Silver-Iron in a simplified way.

We set up the accumulator mounting shown in figure 3:

- S_1 is an aqueous solution of iron (II) sulfate $Fe^{2+}_{(aq)}+SO^{2-}_{4(aq)}$ of an initial molar concentration $C_1=0,2\,mol.L^{-1}$ and volume $V_1=100\,mL$.

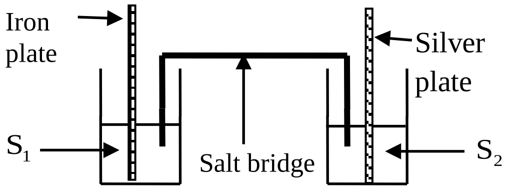


Figure 3

- S_2 is an aqueous solution of silver nitrate $Ag^+_{(aq)}+NO^-_{3(aq)}$ of initial molar concentration $C_2=C_1$ and volume $V_2=V_1$.

Given: - Faraday constant: $1F=9,65.10^4\ C.mol^{-1}$,

- Ox/Red Pairs: $Ag^+_{(aq)}/Ag_{(s)}$; $Fe^{2+}_{(aq)}/Fe_{(s)}$.

The accumulator is linked at t=0 to a lamp. The intensity of the electric current I in the circuit is considered constant: $I=150\ mA$.

0,5 **1-** The spontaneous reaction occurred is the reduction of the silver ions and the oxidation of the iron. Write the overall equation of the reaction during the accumulator functioning.

0,5 **2-** Show that the molar concentration $\left[Ag^{+}_{(aq)}\right]$ at an instant of time t of the accumulator functioning is: $\left[Ag^{+}_{(aq)}\right]_t = 0,2 - 1,55.10^{-5}.t$; where t is expressed in second and the molar concentration is expressed in $mol.L^{-1}$ (we assume that the metallic species are in excess).

0,5 **3-** Determine the functioning time t_d of the accumulator, and the final molar concentration of iron(II) ions : $\left[Fe^{2+}_{(aq)}\right]_f$.

Physics :(13 points)

Exercise 1 : ultrasonic waves (2,25 points)

The ultrasound scanning examination is a tool of medical diagnosis. This technique uses ultrasound sensory.

1- Determination of the speed of an ultrasonic wave in the air

We offer to determine the speed of an ultrasonic wave in the air by the measurement of the wavelength λ of a signal transmitted by a sensory of an ultrasound transducer of frequency $N = 40\,kHz$.

To do that, we use a transmitter E producing periodic sinusoidal ultrasonic waves with the same frequency N as the one transmitted by the sensory.

The receivers R1 and R2 are placed at equal distances away from the transmitter E. When we move the receiver R2 away from R1 with a distance d (figure 1), the two sinusoids viewed on the oscilloscope shift. The two curves being in phase each time the distance d between the two receivers is a multiple n of λ where $n \in \mathbb{N}^*$.

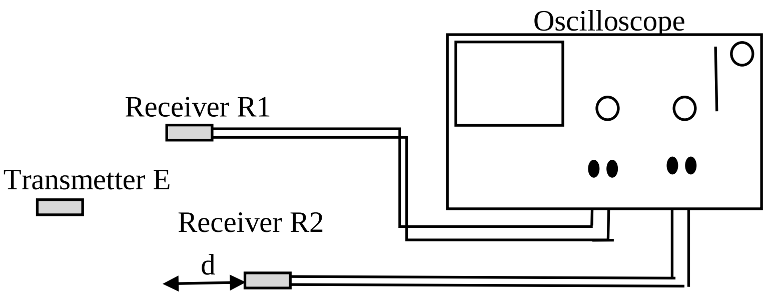


Figure 1

0,25 **1-1-** Define the wavelength.

0,25 **1-2-** Choose the correct answer from the proposals below:

a- The ultrasounds are waves which transfer the matter;

b- The ultrasounds are mechanical waves;

c- The ultrasounds travel through all mediums with the same speed;

d- The boundaries of wavelength of ultrasound waves is $400\,nm \le \lambda \le 800\,nm$.

0,5 **1-3-** In the achieved experiment we measure, for n=12, the distance d=10.2 cm. Determine the speed of the wave in the air.

0,5 **2- Application to the ultrasound scanning:**

The used sensory which acts at the same time as a transmitter and a receiver. When waves travel in the human body, a part of waves is reflected at the boundary between two different mediums. The part reflected is received and analyzed by a computing system.

Figure 2 represents the diagram of the device allowing the scanning of a fetus.

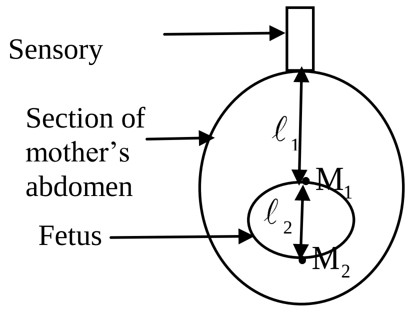


Figure2

During the examination, a wave is transmitted at the instant t=0. The wave reflects at the point M_1 and at the point M_2 . The sensory detects the first reflected waves at the instant $t = t_1 = 80\,\mu s$ and the second one at the instant $t = t_2 = 130\,\mu s$.

Find out the thickness ℓ_2 of the fetus.

We admit that the speed of ultrasonic waves in human body is $v_c = 1540\,m.s^{-1}$.

3- Diffraction of ultrasonic waves in the air:

The experimental mounting represented in figure 3 consists of:

- the transmitter E which transmits the ultrasonic wave of frequency $N = 40\,kHz$.
- the receiver R1 linked to an oscilloscope.
- a metallic plate (P) containing a rectangular hole with a very small width a compared to its length.
- a graduated paper allowing the measurement of angles in degrees.

We displace horizontally the receiver R1 by an angle θ on the arch of the circle of a centre F and radius $r = 40\,cm$, and we note the value of the angle of each received wave's amplitude U_m by R1.

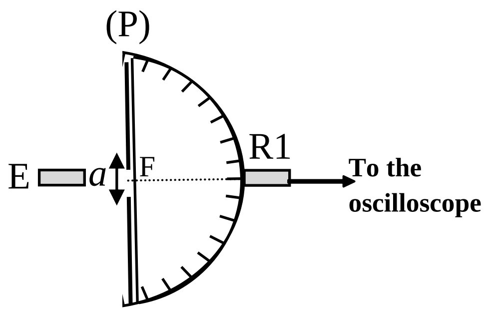


Figure 3

0,25 **3-1-** Compare the wavelength of the incident wave with that of the diffracted wave.

0,5 **3-2-** We give $a = 2,6\,cm$.

Find out the distance of the displacement of the receiver to observe the first minimum of the amplitude U_m of the voltage between the terminals of the receiver.

Exercise 2 : Electricity (5,25 points)

Circuits of electric devices, used in many domains of daily life, are made up of capacitors, conductors, resistors and integrated circuits ...

The aim of the first part of this exercise is the study of (R, L) dipole and (L, C) circuit. The second part aims is studying the amplitude modulation (AM).

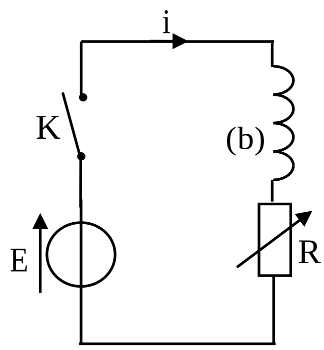


Figure1

I- Part I: Response of the RC circuit to a step of voltage.

We set up the mounting shown in figure 1 which consists of:

- a power supply G of voltage; Its electromotive force is $E = 1,5\,V$,
- a resistor of adjusted resistance R;
- an inductor (b) of inductance L and of resistance r ;
- a switch K;

The switch K is closed, at an instant assumed as origin of time (t=0). We follow the evolution of the intensity of the electric current i(t) using an appropriate datalogger system.

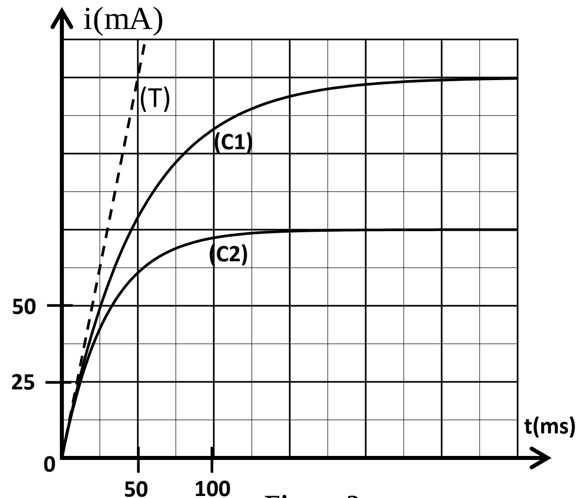


Figure 2

0,25 **1-1-** Establish the differential equation for i(t).

0,5 **1-2-** The solution of the differential equation is :

$i(t) = A.e^{-\alpha t} + B$, where A , B and α are constants.

Find out the expression of i(t) in terms of t and the parameters of the circuit .

1-3- The curves (C1) and (C2) in figure 2 represents the evolution of i(t) respectively for $R = R_1$ and $R = 2R_1$. ((T) represents the tangent of the curve (C1) at the instant t=0).

0,5 **1-3-1-**Find out R_1 and r.

0,5 **1-3-2-** Show that $L=0,6H$.

2- Study of LC circuit

In this study we use an inductor (b') of inductance L=0.6H and of negligible resistance.

After the total charge of a capacitor of capacitance C, using a constant voltage U_0, we connect it to terminals of the inductor (b') (Figure 3).

The voltage between terminals of the capacitor can be written as:

$u_C(t)=U_0.\cos(2\pi f_0 t+\varphi)$, where f_0 is the natural frequency of the circuit.

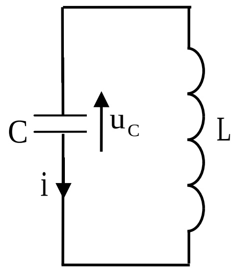


Figure 3

0,25 **2-1-** Show that the total electric energy E_t of the circuit is constant.

0,75 **2-2-** The curve shown in figure 4 represents the variations of the magnetic energy E_m stored in the inductor as a function of the square of the voltage u_C between terminals of the capacitor: $E_m=f(u_C^2)$.

Based on the curve shown in figure 4, find out the capacitance C of the capacitor and the voltage U_0.

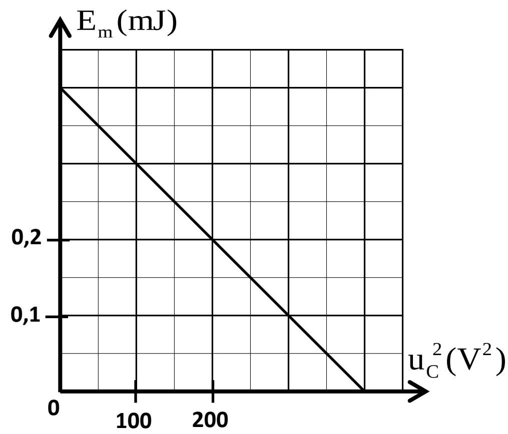


Figure 4

Part II : Amplitude modulation

In order to produce an amplitude-modulated radio wave, we set up the mounting in figure 5, where X is an integrated multiplier circuit. The coefficient of the multiplier circuit is k.

We apply at the input E_1 the voltage $u_1(t)=6.\cos(4.10^5\pi.t)$ and at the input E_2 the voltage $u_2(t)=2.\cos(8.10^3\pi.t)+5$.

At the output, we obtain voltage

$u_s(t)=k.u_1(t).u_2(t)=3[1+0,4.\cos(8.10^3\pi t)].\cos(4.10^5\pi t)$.

All voltages are expressed in volt (V).

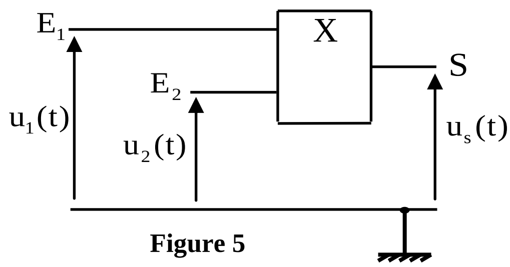


Figure 5

0,25 **1-** Find out the frequency of the carrier wave.

0,5 **2-** Choose the correct answer:

The maximum amplitude of the modulated wave is:

a- 6V ; **b-** 4.2V ; **c-** 3V ; **d-** 1.8V ; **e-** 2V.

0,5 **3-** Are the conditions, of obtaining a high quality of modulation, verified? Justify your answer.

0,75 **4-** Express $u_s(t)$ as the sum of three sinusoidal functions and draw a graph showing the spectrum of this modulated wave; by choosing the following scale: 1cm/V for the amplitude.

Reminder: $\cos(a).\cos(b)=\frac{1}{2}[\cos(a+b)+\cos(a-b)]$.

0,5 **5-** Can the bung circuit, made up by the previous capacitance and inductor, allow the good reception of the studied modelled wave? Justify your Answer.

<u>Exercise 3 : Mechanics (5,5 points)</u> Part I and Part II are independent

Part I: The motion of a skier.

This part of exercise describes a simplified model of the motion of the centre of inertia G of a skier in two stages of his courses:

- First stage: straight motion of the skier on inclined plan;
- Second stage: free fall of the skier in a uniform gravitational field.

Given: -Mass of the skier: $m=60\,kg$;

- Intensity of the gravitational acceleration: $g=9,8\,m.s^{-2}$

We neglect the air actions.

1- First stage: motion of the skier in an inclined plan.

We study the motion of the centre of inertia G in the frame of reference $R(O,\vec{i_1},\vec{j_1})$ linked to the earth assumed galilean(figure 1)..

To achieve the top S of a straight runway (P) inclined at the angle $\alpha=23°$ to the horizontal plane, the skier starts off from the point O without initial velocity at t=0.

The skier is hung on an inflexible cable at the angle $\beta=60°$ to the horizontal plane. The cable acts on the skier by the constant force of the action $\vec{F}$ which has the same direction of the cable(figure 1).

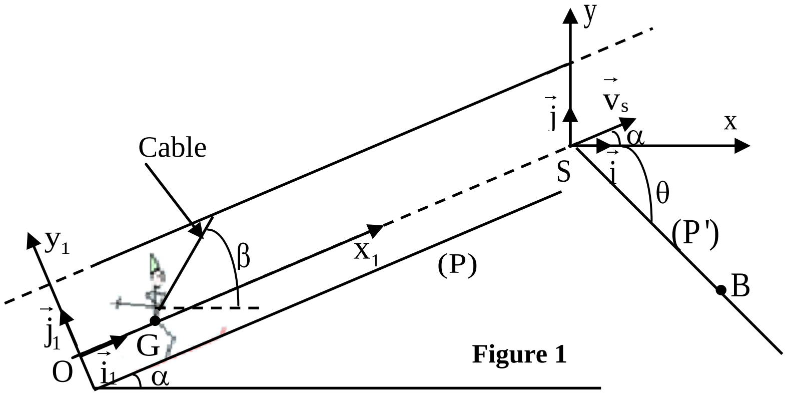


Figure 1

During this phase of motion, the skier stays in touch with the floor. We note $\vec{R}_T$ and $\vec{R}_N$ respectively the tangential and the normal component of the action of the inclined plan on the skier, where $\|\vec{R}_T\|=k\|\vec{R}_N\|$, k is the coefficient of friction and $\|\vec{R}_T\|=f=80\,N$.

0,5 **1-1-** By applying Newton's second law, show that the differential equation for the velocity v of the centre of inertia G is written as: $\frac{dv}{dt}+\frac{f}{m}+g.\sin\alpha-\frac{F}{m}\cos(\beta-\alpha)=0$.

1-2- The curve in figure 2 shows the variations of the velocity as a function of time.

0,25 **1-2-1-** Find out graphically the value of the acceleration of G.

0,25 **1-2-2-** Deduce the value of the magnitude of the force of the action $\vec{F}$.

0,5 **1-3-** Compute the value of k.

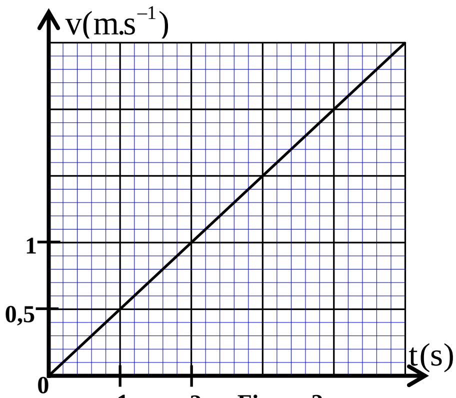


Figure 2

2-Second stage: jumping phase

The skier achieves the top S of the runway (P), he releases the cable and leaves the runway at an instant of time chosen as a new origin of time (t=0) with the velocity $\vec{v}_S$ at an angle α to the horizontal plane and of value $v_S=10\,m.s^{-1}$(figure1).

We study the motion of the centre of inertia in the frame of reference $R(S,\vec{i},\vec{j})$ linked to the earth assumed galilean.

That is to say, B is the position of G on the runway (P') which is inclined at the angle $\theta=45°$ of the horizontal plane (figure 1).

0,5 **2-1-** Establish the parametric equations of motion x(t) and y(t) of the free fall of G in the frame of reference $(S,\vec{i},\vec{j})$.

0,5 **2-2-** Deduce that the equation of the path (trajectory) is given by: $y=-5,8.10^{-2}\,x^2+0,42x$.

0,5 **2-3-** find out the jumping length SB.

Part II: Motion of a simple pendulum

We consider a metronome which is modelled by a simple pendulum consisting of a rigid rod of a negligible mass and of length $\ell = 24,8\,cm$, on which a small ball, of mass $m = 20\,g$ and of negligible dimensions about ℓ, is hung.

When we move apart the pendulum from its equilibrium position by an angle θ_m, it oscillates in the vertical plan between terminals positions A and B around the horizontal axis (Δ) through O (figure 3).

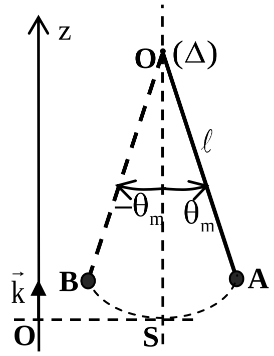


Figure 3

The metronome transmits an acoustic signal when the sphere reaches the point A and transmits the same acoustic signal when it reaches the point B.

We locate the position of the pendulum by the angular displacement θ at an instant of time t.

Given : - The magnitude of the gravitational acceleration: $g = 9,81\,m.s^{-2}$

- For the small oscillations amplitude, we take $\cos\theta \approx 1 - \frac{\theta^2}{2}$; θ in radian;
- The moment of inertia of the pendulum about the axis (Δ) is: $J_\Delta = m.\ell^2$.

The frictions are negligible.

1- We move apart the pendulum from its equilibrium position, with a small angle $\theta_m = 8°$ and then we release it form the position A at the instant $t_0 = 0$ without an initial velocity.

We choose that the gravitational potential energy to be zero $(E_{pp}(O) = 0)$ on the horizontal plane passes through the position of the small ball at the point S.

0,5 **1-1-** Find out the expression of the gravitational potential energy of the pendulum at an instant of time t in terms of θ, ℓ, m and g.

0,25 **1-2-** Compute the value of the mechanical energy of the pendulum.

0,5 **1-3-** Based on the study of the energy, establish the differential equation of motion of the angular displacement $\theta(t)$.

2- We denote the natural period of the pendulum by T_0.

0,5 **2-1-** Give the expression of T_0 in terms of g and ℓ and, by using the dimensional equations, verify that it is homogenous to a time.

0,5 **2-2-** Calculate the value of T_0. Deduce how many acoustic signals will be transmitted during the time $\Delta t = t - t_0 = 10,25\,s$ knowing that the first acoustic signal is transmitted when the small ball reaches the point B for the first time.

0,25 **3-** Based on the conservation of the mechanical energy, show that the angular velocity $\dot{\theta}(t)$ at an instant t is expressed by the relation: $\dot{\theta}(t) = \pm\dot{\theta}_S\sqrt{1 - \left(\frac{\theta}{\theta_m}\right)^2}$ where $\dot{\theta}_S$ is the angular velocity at the point S.