المملكة المغربية
وزارة التربية الوطنية
والتكوين المهني
والتعليم العالي والبحث العلمي

ⵜⴰⴳⵍⴷⵉⵜ ⵏ ⵍⵎⵖⵔⵉⴱ
ⵜⴰⵎⴰⵡⴰⵙⵜ ⵏ ⵓⵙⴳⵎⵉ ⴰⵏⴰⵎⵓⵔ
ⴷ ⵓⵙⵎⴻⵜⵜⵉ ⴰⵣⵣⴰⵢⴰⵏ
ⴷ ⵓⵙⵍⵎⴷ ⴰⵏⴰⴼⵍⵍⴰ ⴷ ⵓⵔⵣⵣⵓ ⴰⵎⴰⵙⵙⴰⵏ

المركز الوطني للتقويم والامتحانات والتوجيه

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة العادية 2019
-الموضوع-
NS28E

3	مدة الانجاز	الفيزياء والكيمياء	المادة
7	المعامل	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	الشعبةأوالمسلك

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

Literal expressions should be given before doing numerical calculations.

This exam paper consists of four exercises;

Exercise I (7 points)

- Electrolysis of an aqueous solution of the zinc iodide
- Conductiometric study of an aqueous solution of the benzoic acid

Exercise II (3,5 points)

- Propagation of a mechanical wave
- Disintegration of radon-222

Exercise III (4,5 points)

- Charging and discharging of a capacitor

Exercise IV (5 points)

- Motion of the center of inertia of a mechanical system

Marking scale

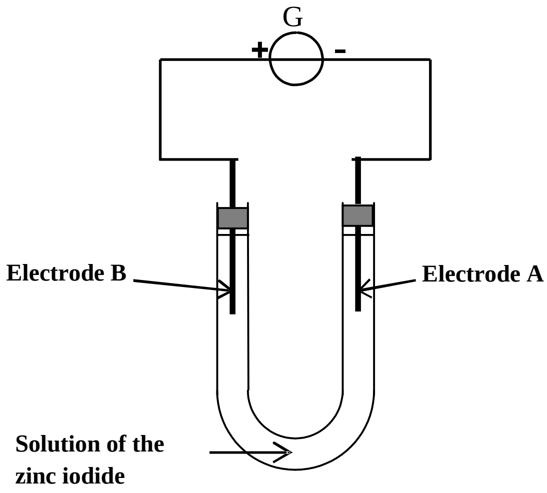
Exercise I (7 points)

Part 1 and Part 2 are independent

Part 1 – Electrolysis of an aqueous solution of the zinc iodide

We carry out the electrolysis of an aqueous solution of zinc iodide $Zn^{2+}_{(aq)} + 2I^{-}_{(aq)}$ using two electrodes of graphite A and B. The zinc metal is deposited at one electrode and the iodine gas is released at the other electrode.

The figure at right represents the schema of the experimental set-up to perform this electrolysis.



Given:

- ✓ $1F = 9,65.10^{4}\ C.mol^{-1}$;
- ✓ The two redox pairs involved in the reaction are : $Zn^{2+}_{(aq)} / Zn_{(s)}$ and $I_{2(g)} / I^{-}_{(aq)}$;
- ✓ The molar mass of the zinc is $M(Zn) = 65,4\ g.mol^{-1}$.

0,5 **1.** Which of the electrodes A and B is the anode? Justify your answer.

0,75 **2.** Write the half-equation of the reaction occurring at each electrode and the overall equation of this electrolysis.

0,75 **3.** For a duration Δt of this electrolysis, an electric current of constant intensity $I = 0,5\,A$ flows over this circuit and a mass $m = 1,6\,g$ of zinc is formed. Determine Δt in minutes.

Part 2 – Conductiometric study of an aqueous solution of the benzoic acid

The benzoic acid of formula C_6H_5COOH *is known as a food preservative existing in soft drinks. It can be used as an antiseptic medicine.*

This exercise aims at determining pK_A *the constant of the acid-base pair* $C_6H_5COOH_{(aq)} / C_6H_5COO^{-}_{(aq)}$ *by Conductiometric study.*

Given:

- The molar ionic conductivity at 25°C : $\lambda_1 = \lambda(H_3O^+) = 35.10^{-3} S.m^2.mol^{-1}$ and $\lambda_2 = \lambda(C_6H_5COO^-) = 3,23.10^{-3} S.m^2.mol^{-1}$

- The expression of the conductivity σ of an aqueous solution as a function of the effective molar concentrations and the molar ionic conductivities λ_i of the chemical species X_i in a solution is given by $\sigma = \sum \lambda_i [X_i]$.

At 25°C, we prepare an aqueous solution S of the benzoic acid of concentration $C = 10^{-3} mol.L^{-1}$ and of volume V = 1L.

0,5 **1.** Write the equation of the reaction between the benzoic acid and water.

0,75 **2.** Draw the progress table of this reaction.

3. The measurement of the conductivity of the solution S gives $\sigma = 8,6.10^{-3} S.m^{-1}$.

0,75 **3.1.** Express σ in terms of λ_1, λ_2 and $[H_3O^+]$ the effective molar concentration of the oxonium ions at equilibrium. (Assuming that the impact of the hydroxide ions HO^- on the conductivity of the solution is negligible).

0,75 **3.2.** Show that the final progress rate τ of the reaction is written as $\tau = \dfrac{\sigma}{C(\lambda_1 + \lambda_2)}$. Calculate its value.

0,75 **4.** Find out the expression of K the equilibrium constant associated to the reaction between the benzoic acid and water, in terms of C and τ.

0,25 **5.** What is represented by K the equilibrium constant corresponding to this reaction?

0,75 **6.** Deduce the value of pK_A of the pair $C_6H_5COOH / C_6H_5COO^-$.

0,5 **7.** Which of the two chemical species C_6H_5COOH and $C_6H_5COO^-$ is predominant in the solution S ?

Exercise II (3,5 points)

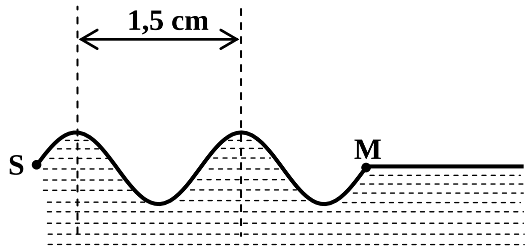
Part 1 and 2 are independent.

Part 1- Propagation of a mechanical wave

To study the propagation of mechanical waves on the surface of water, we use a ripple tank. The aim of this part is to determine some specific quantities of a mechanical wave.

Using a vibrating bar of a ripple tank, a sinusoidal progressive wave of frequency $N = 20Hz$ *is generated at a point S on the surface of water. This wave propagates from S at t=0 without damping and reflection.*

The figure on the right represents the shape of the surface of water at an instant t_1 of time.



0,5 **1.** Is the wave which travels on the surface of water a longitudinal or transverse wave? Justify.

0,25 **2.** Determine λ the wavelength of this wave.

0,5 **3.** Deduce V, the wave speed of this wave.

0,5 **4.** The wavefront of this wave is at point M which is far from S by a distance d=SM at an instant t_1. Express the time delay τ of the displacement of M to the displacement of S, in terms of the period T of this wave. Calculate τ.

Part 2- Study of the disintegration of the radon-222

The radon of symbol Rn is a radioactive gaseous element existing naturally in the atmosphere. It is formed by consecutive decays of the uranium present in the granite rocks.

Many isotopes of the radon are known. The radon-222 is radioactive. In this exercise we suggest to study the disintegration of this isotope.

Given :

- The half-life of the radon-222 is $t_{1/2} = 3,8\,days$.
- Table of some binding energies per nucleon :

Nucleus	Helium	Radon	Polonium
Symbol	$^{4}_{2}He$	$^{222}_{86}Rn$	$^{218}_{84}Po$
Binding energy per nucleon (MeV / nucleon)	7,07	7,69	7,73

0,5 **1.** Which of the nuclei $^{222}_{86}Rn$ and $^{218}_{84}Po$ is the most stable? Justify.

0,25 **2.** Show that the binding energy of the helium nucleus $^{4}_{2}He$ is $E_b(He) = 28,28\,MeV$.

0,5 **3.** The equation of the disintegration of the radon-222 is written as $^{222}_{86}Rn \rightarrow ^{218}_{84}Po + ^{4}_{2}He$.

Choose the right answer.
The energy released (produced) over this disintegration of the nucleus radon-222 is :

■ $E_{pro} = 7,11$ MeV ■ $E_{pro} = 22,56$ MeV ■ $E_{pro} = 6,24$ MeV ■ $E_{pro} = 3420,6$ MeV

0,5 **4.** We consider a_0 the activity of a sample of nuclei radon-222 at t = 0.

Determine, in days unit, the instant t_1 at which the activity of this sample will be $a_1 = \frac{a_0}{4}$.

Exercise III (4,5 points)

Charging and discharging of a capacitor

Capacitors and inductors are the main components of many electric devices such as those used in emission and reception devices of the electromagnetic waves.

This exercise aims at studying the charging of a capacitor and its discharging in an inductor.

We set up the mounting sketched in figure 1. This mounting is consisted of these components:
- an ideal power supply of electromotive force E =10V ;
- a capacitor of capacitance C initially discharged;
- a resistor of resistance R ;
- an inductor of inductance L and of negligible resistance ;
- a double switch K.

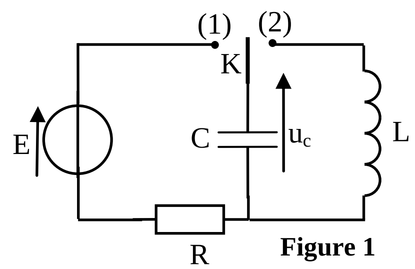


Figure 1

I –Study of the charging of the capacitor

We put the switch K at position (1) at an instant taken as an origin of time (t = 0). An appropriate datalogger permits to draw the curve of the evolution of the charge q(t) of the capacitor.

Line (T) represents the tangent of the curve at t=0 (figure 2).

0,5 **1.** Find out the differential equation verified by q(t) during the charging of the capacitor.

0,5 **2.** Find the expressions of the constants A and α in terms of the circuit's parameters where $q(t) = A(1 - e^{-\alpha t})$ is the solution of the differential equation.

3. Determine graphically :

0,25 **3.1.** The value of the charge Q of the capacitor when the steady state is reached.

0,25 **3.2.** The value of the time-constant τ.

0,25 **4.** Show that the capacitance of the capacitor is: $C = 10\mu F$.

0,25 **5.** Calculate the value of the resistance R.

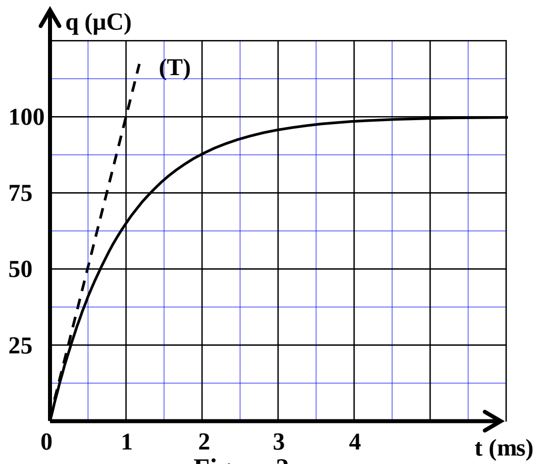


Figure 2

II-Study of the electric oscillations in the LC circuit

When the steady state is reached, we put the switch K at position (2) at an instant taken as a new origin of time (t=0). We visualise, using an appropriate device, the variations of the voltage u_c between terminals of the capacitor as a function of time.

0,25 **1.** Show that the differential equation verified by the voltage $u_c(t)$ between terminals of the capacitor is written as :

$$\frac{d^2u_c}{dt^2} + \frac{1}{LC}u_c = 0$$

2. For this experiment, one of the three following curves (a), (b) or (c) in figure 3 represents the variations of the voltage $u_c(t)$.

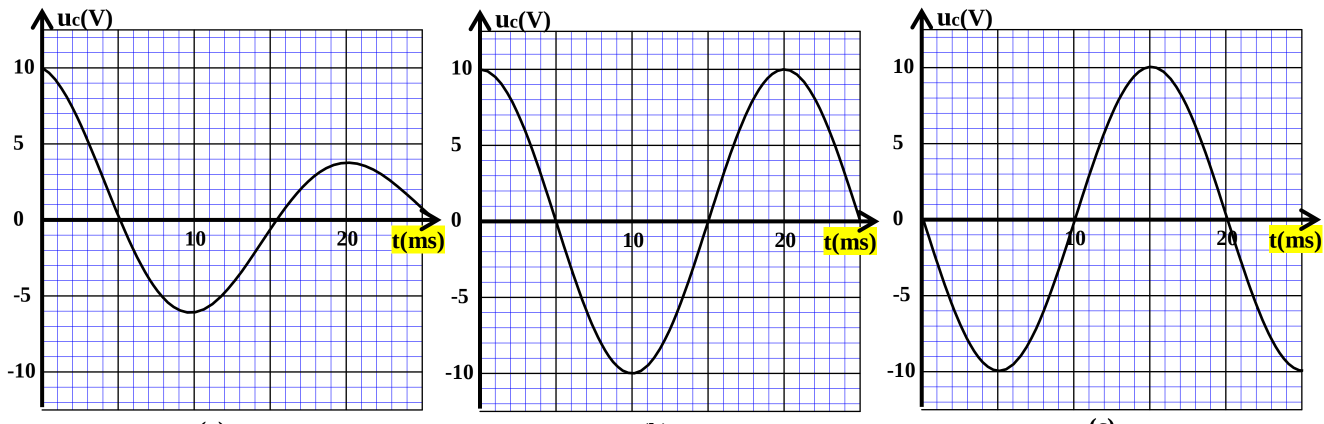


Figure 3

0,5 **2.1.** State which curve represents the variations of the voltage $u_c(t)$ for this experiment. Justify your answer

0,25 **2.2.** Determine the natural period T_0 of the LC oscillator.

0,5 **3.** Determine the inductance L of the inductor. (take $\pi^2 = 10$).

4. Using the curve $u_c(t)$ of the variation for this experiment,

0,5 **4.1.** find the total electric energy E_t of the circuit.

0,5 **4.2.** deduce the magnetic energy E_{m1} stored in the inductor at the instant $t_1 = 12\,ms$.

Exercise IV (5 points)

Study of the motion of the center of inertia of a mechanical system

The long jump using a motorcycle is a competition where jumping as far as possible from a specific positionis a serious challenge.

This exercise aims at studying the motion of the center of inertia of a mechanical system (S) which is consisted of a motorcycle and a motorcyclist on a competition track.

This track is consisted of :

- a rectilinear incline part A'B' at an angle β to the horizontal ;
- a circular take-off ramp $B'C'$;
- a landing ramp (π) which is planar and horizontal (figure 1 page 6/7).

We neglect all frictions and we study the motion of G the center of inertia of the system (S) in a geocentric frame of reference assumed Galilean.

Given :

- The value of the angle β is $\beta = 10°$;
- Gravitational field strength is $g = 10\ m.s^{-2}$;
- Mass of the mechanical system (S) is m =190 kg.

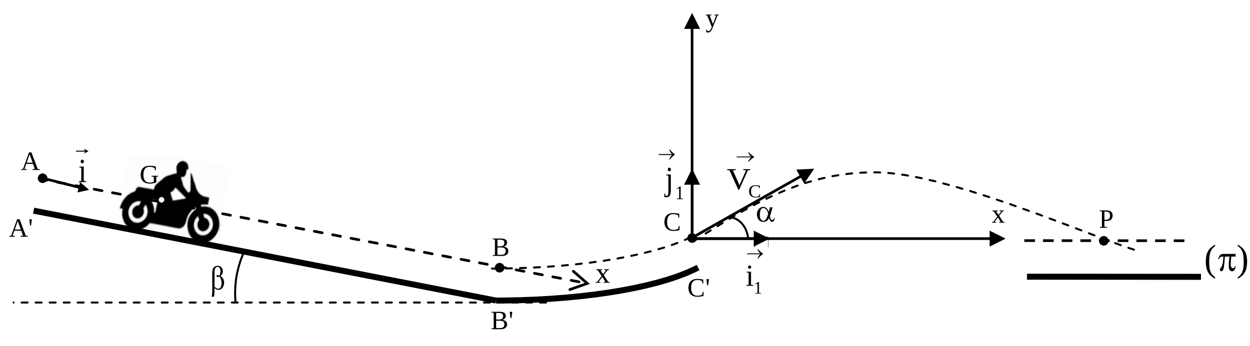


Figure 1

I- Study of the motion on A'B' part

At an instant assumed as an origin of time (t = 0), the system starts without initial velocity from a position where the center of inertia G coincides with point A.

During this motion on this part A'B', the system experiences the reaction of the plane, the weight and a constant motive force $\vec{F}$ whose direction is parallel to the path of G and its sense is the same as that of the motion. The study of the motion in this part is done in the coordinate system of space $(A, \vec{i})$ which is parallel to A'B' and the position of G is located by its abscissa x (Figure 1).

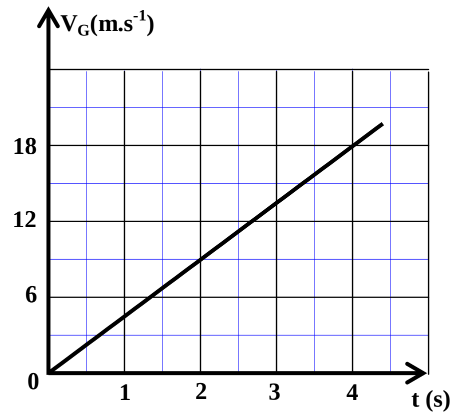


Figure 2

0,5 **1.** Applying Newton's second law, show that the acceleration a_G of the motion of G is written as :

$$a_G = \frac{F}{m} + g.\sin\beta$$

0,5 **2.** The curve in figure 2 represents the variations of the instantaneous velocity V_G of the center of inertia G as a function of time. Using the curve in figure 2, determine the value of the acceleration a_G .

0,5 **3.** Deduce the magnitude F of the motive force.

0,5 **4.** Write the numerical expression of the parametric equation x = f(t) of the motion of G.

0,5 **5.** Knowing that the distance AB = 36 m, determine the instant t_B when the center of inertia G passes by point B.

0,5 **6.** Calculate the speed V_B when the center of inertia G passes by point B.

II- Study the motion of G during the jumping

At an instant taken as a new origin of time (t=0), the system (S) leaves the take-off ramp when G passes through point C with the velocity $\vec{V}_C$ at angle $\alpha = 18°$ to the horizontal.

The system (S) falls back where G coincides with point P. During the jumping phase, we assume that the weight is the only force acting up on the system. The motion is done on the orthonormal coordinate system $(C, \vec{i}_1, \vec{j}_1)$ shown in figure 1.

0,5 **1.** Applying Newton's second law, show that the differential equations verified by coordinates $x_G(t)$ and $y_G(t)$ of the center of inertia G in the coordinate system $(C,\vec{i_1},\vec{j_1})$ are written as:

$$\frac{dx_G}{dt}=V_C.\cos\alpha \qquad \text{and} \qquad \frac{dy_G}{dt}=-g.t+V_C.\sin\alpha$$

0,5 **2.** Knowing that the numerical parametric equations $x_G(t)$ and $y_G(t)$ of the motion of G are:

$x_G(t)=19{,}02.t$ and $y_G(t)=-5.t^2+6{,}18.t$ (x_G and y_G are expressed in meters and t in seconds)

Verify that the speed of G at point C is $V_C=20\,m.s^{-1}$.

3. A jump is considered succeful when $CP\geq 30\,m$.

0,5 **3.1.** Show that the jump of the motorcyclist in this case has failed.

0,5 **3.2.** Determine V_{min} the minimum speed in which the center of inertia G must be passing by point C for the jump to be succeful.

الامتحان الوطني الموحد للبكالوريا
المسالك الدولية – خيار أنجليزية
الدورة العادية 2019
- عناصر الإجابة -
NR28E

المملكة المغربية
وزارة التربية الوطنية والتكوين المهني والتعليم العالي والبحث العلمي
المركز الوطني للتقويم والامتحانات والتوجيه

المادة	الفيزياء والكيمياء	مدة الانجاز	3
الشعبة أو المسلك	شعبة العلوم التجريبية : مسلك العلوم الفيزيائية – خيار أنجليزية	المعامل	7

Exercise I (7 points)

	Question	Answers	Marking scale	Question reference in the framework
Part I	1	(B) is the anode + justification	0,25x2	- Recognize the anode electrode (oxidation) and the cathode electrode (reduction) using the flow of electric current imposed by an external voltage supply.
	2	At the anode : $2I^- \rightleftarrows I_2 + 2e^-$ At the cathode : $Zn^{2+} + 2e^- \rightleftarrows Zn$ Overall equation : $Zn^{2+} + 2I^- \rightarrow Zn + I_2$	0,25 0,25 0,25	- Write the half-equation that occurred in each electrode (use double arrows) and write the overall equation of the reaction during electrolysis (use one arrow).
	3	$\Delta t = \frac{2.m.F}{I.M(Zn)}$ $\Delta t \approx 157,4\,min$	0,5 0,25	- Establish the relationship between the amount of substance of chemical specie produced or consumed the current intensity and the operating duration of electrolysis. Use this relationship to determine other quantities (quantity of charge, progress of the reaction, change of the mass, volume of a gas, etc.).
Part II	1.	$C_6H_5COOH + H_2O \rightleftarrows C_6H_5COO^- + H_3O^+$	0,5	- Write the equation of the acid-base reaction and identify the two pairs involved.
	2.	Progress table	0,75	- Draw the progress table of a reaction and exploit it.
	3.1.	Method $\sigma = (\lambda_1 + \lambda_2)\left[H_3O^+\right]$	0,5 0,25	- Use the relationship linking the conductance G of a solution part to the effective molar concentrations [Xi] of Xi ions in the solution.
	3.2.	Method $\tau \approx 0,22$	0,5 0,25	- Calculate the final progress of the reaction that occurs between an acid and water taking into consideration the value of both the concentration and this acid's pH aqueous solution; then, compare it with the maximum progress.
	4.	Method $K = \frac{C.\tau^2}{1-\tau}$	0,5 0,25	- Know that, the reaction quotient in equilibrium $Q_{r,eq}$, associated to the reaction equation of a chemical system, takes a value independent of concentrations, called equilibrium constant K.
	5.	The acid dissociation constant	0,25	- Write and use the expression of the acid dissociation constant K_A associated with the reaction of an acid with water.
	6.	$pK_A = -\log K_A = -\log K$ $pK_A \approx 4,2$	0,5 0,25	- Know the relationship pK_A= -logK_A.
	7.	The predominant chemical specie is the benzoic acid + method	0,25x2	- Indicate the predominant chemical specie taking into consideration pH of aqueous solution and pK_A of pair acid/base.

Exercise II (3,5 points)

	Question	Answers	Marking scale	Question reference in the framework
Part 1	1.	Transverse wave + justification	0,25x2	- Define a mechanical wave and its wave speed. - Define a transverse wave and a longitudinal wave. Exploit experimental documents and data in order to determine: * distance; * time delay; * wave speed. Know (Recall) and use the relationship $\lambda = v.T$
	2.	$\lambda = 1{,}5\,cm$	0,25	
	3.	$V = \lambda.N$ $V = 0{,}3\,m.s^{-1}$	0,25 0,25	
	4.	$\tau = 2.T$ $\tau = 0{,}1\,s$	0,25 0,25	
Part 2	1.	The polonium 218 is the most stable nucleus + justification	0,25x2	- Exploit the binding energy per nucleon curve (Aston curve) to identify the most stable nucleus. - Define and calculate the binding energy per nucleon and exploit it.
	2.	Method	0,25	
	3.	$E_{pro} = 6{,}24\ MeV$	0,5	- Calculate the energy released (produced) by a nuclear reaction: $E_{pro} = \lvert\Delta E\rvert$.
	4	Method $t_1 = 7{,}6\,days$	0,25 0,25	- Know and exploit the law of the radioactive decay, and exploit its curve.

Exercise III (4,5 points)

Question		Answers	Markings cale	Question reference in the framework
I-	1.	Method $\frac{dq}{dt} + \frac{1}{R.C}q = \frac{E}{R}$	0,25 0,25	- Know and exploit the relationship $i = \frac{dq}{dt}$ for a capacitor in receiver convention. - Know and exploit the relationship q = C.u. - Find out the differential equation and verify its solution when the RC dipole is submitted to a step voltage. - Determine the voltage expression $u_C(t)$ between capacitor terminals when the RC dipole is submitted to a step voltage, and deduce both the expression of the intensity current in the circuit and the capacitor charge. - Know and exploit the time-constant expression. - Use the dimensional analysis (dimensional equations). - Exploit experimental documents in order todetermine the time-constant and charge duration.
	2.	$\alpha = \frac{1}{RC}$ $A = C.E$	0,25 0,25	
	3.1.	$Q = 100\,\mu C$	0,25	
	3.2	$\tau = 1\,ms$	0,25	
	4.	Method	0,25	
	5.	$R = \frac{\tau}{C}$; $R = 100\ \Omega$	0,25	
II-	1.	Method	0,25	- Find out the differential equation for the voltage between the capacitor terminals or for its charge $q(t)$ in the negligible damping case and verify its solution.

	2.1.	Curve (b) justification	0,25 0,25	- Exploit experimental documents in order to: * recognize the observed voltages; * determine the values of the period and the natural period.
	2.2.	$T_0 = 20\ ms$	0,25	
	3.	$L = \dfrac{T_0^2}{4\pi^2.C}$ $L = 1H$	0,25 0,25	- Know and exploit the natural period expression.
	4.1.	Method $E_t = 5.10^{-4} J$	0,25 0,25	- Know and exploit the expression of the total energy in the circuit.
	4.2.	$E_{m1} = E_t - E_e(t_1)$ $E_{m1} = 1{,}8.10^{-4} J$	0,25 0,25	

Exercise IV (5 points)

Question		Answers	Markings cale	Question reference in the framework
I-	1.	Method	0,5	- Know and exploit the characteristics of the uniformly accelerated straight line motion and its parametric equations (t is the parameter). - Exploit the velocity-time graph: $v_G = f(t)$. - Apply Newton's second law to find out the differential equation of a system's centre of inertia motion in horizontal or inclined plane and determine the characteristics of kinetic and dynamic quantities of motion.
	2.	Method $a_G = 4{,}5 m.s^{-2}$	0,25 0,25	
	3.	$F = m(a_G - g\sin\beta)$ $F = 525{,}1 N$	0,25 0,25	
	4.	$x = 2{,}25.t^2$	0,5	
	5.	Method $t_B = 4\ s$	0,25 0,25	
	6.	$V_B = a_G.t_B$ $V_B = 18\ m.s^{-1}$	0,25 0,25	
II	1.	Method	0,5	- Apply Newton's second law in the case of a projectile to: * find out differential equation of motion; * deduce the parametric equations of motion and exploit them; * establish the equation of the path (trajectory), find out the expressions of the range and the maximum height of the pathand exploit them;
	2.	Method	0,5	
	3.1.	$x_P \approx 23{,}5 m$ CP<30 m , the jump has failed	0,25 0,25	
	3.2.	Method $V_{min} \approx 22{,}6\ m.s^{-1}$	0,25 0,25	