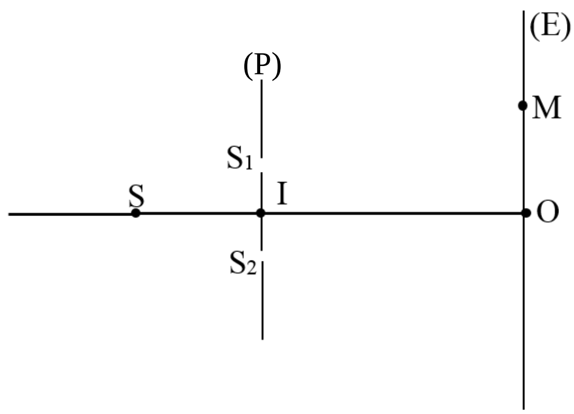
المادة: الفيزياء الشهادة: الثانوية العامّة الفرع: علوم الحياة نموذج رقم 1 المدّة: ساعتان	الهيئة الأكاديميّة المشتركة قسم: العلوم	المركز التربوي للبحوث والإنماء

نموذج مسابقة (يراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

This test is made up of three obligatory exercises in four pages.
The use of non-programmable calculators is allowed.

Exercise 1 (6½ points) Young's slits

Consider the Young's slits device made up of two very thin and horizontal slits S_1 and S_2 separated by a distance a = 1 mm, a screen (E) parallel to the plane containing S_1 and S_2 and a monochromatic light source S.
The screen (E) is at a distance D = 2 m from the midpoint I of $[S_1S_2]$.
The light source (S) is on the perpendicular bisector of $[S_1S_2]$. This bisector meets the screen (E) at a point O.
The wavelength in the air of the monochromatic light is λ = 650 nm.



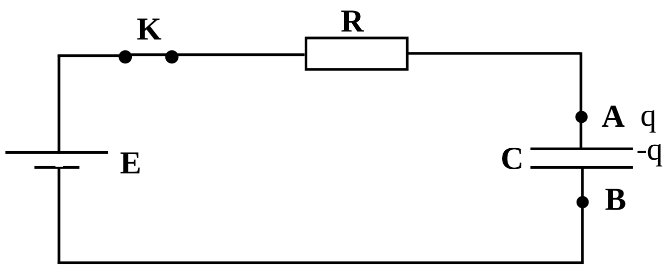
1) A pattern is observed on the screen (E). Indicate the name of the correspondent phenomenon.
2) State and explain the conditions on S_1 and S_2 to obtain this pattern.
3) Consider a point M of the pattern observed on the screen (E) such as $\overline{OM} = x$. Given: $d_1 = S_1M$ and $d_2 = S_2M$. Write the relation that gives the path difference $\delta = d_2 - d_1$ in terms of a, D and x.
4) Define the interfringe distance i.
5) Give the expression of i in terms of λ, D and a then calculate its value.
6) The point O coincides with the centre of a fringe called central fringe.
  6-1) Calculate the path difference δ at O.
  6-2) Specify if this fringe is bright or dark.
7) Let N be the centre of a fringe such as δ = 2,275 μm. Specify if this fringe is bright or dark.
8) S is at a distance d = 10 cm from I. We displace S vertically of a distance y = 1 cm towards S_1. The new path difference is written : $\delta' = \frac{ax}{D} + \frac{ay}{d}$. Tell in which direction the central fringe moves (towards S_1 or towards S_2) and calculate the displacement.

Exercise 2 (6½ points) (RC) circuit.

The electric circuit of the figure (Doc 1) is composed of:
- a generator supplying across its terminals a constant voltage E = 8 V;
- a resistor of unknown resistance R;
- a capacitor of capacitance C = 100 µF, initially discharged;
- a switch K.

At the instant t = 0, we close the switch K.
At an instant t, le capacitor has a charge q and the circuit carries a current i.

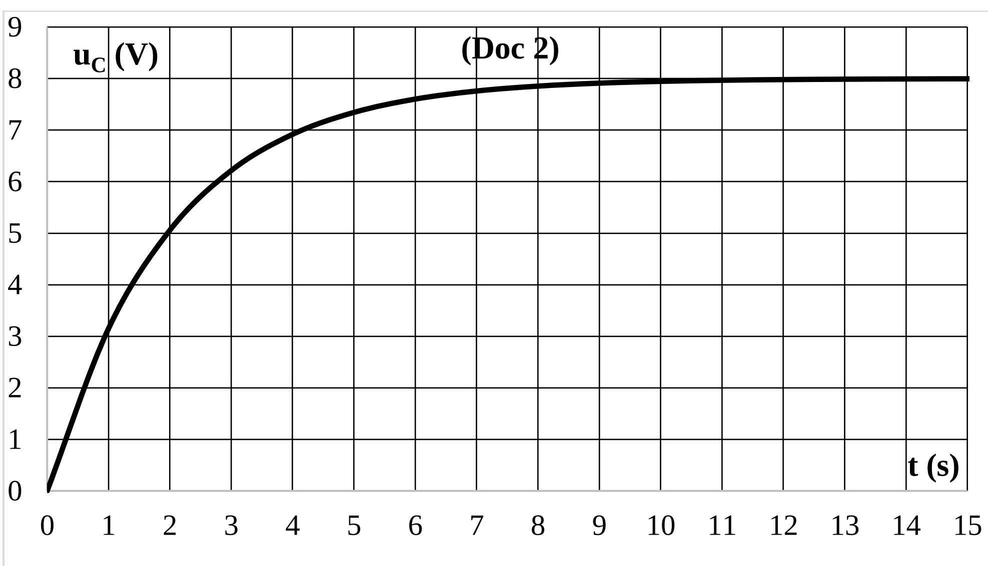
1) Redraw the figure (Doc 1) and show the connections of an oscilloscope that displays the voltage $u_G = E$ across the generator and the voltage $u_C = u_{AB}$ across the capacitor.
2) Write the expression of the current i in terms of q.
3) Deduce the expression of i in terms of the capacitance C and the voltage u_C.
4) Determine the differential equation in terms of u_C.
5) The solution of this differential equation is: $u_C = D\left(1 - e^{-\frac{t}{\tau}}\right)$. Determine the expressions of the positive constants D and τ in terms of E, R and C.



(Doc 1)

6) Determine, at the instant $t = \tau$, the voltage u_C in terms of E.

7) Using the graph of $u_C = f(t)$ of the figure (Doc 2) below:
7-1) Determine the value of τ.
7-2) Deduce the value of the resistance R.



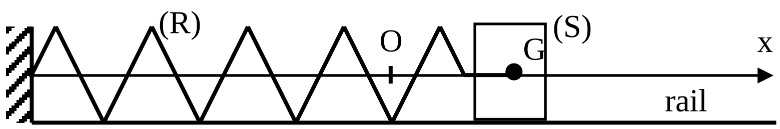
8) Determine the expression of the current i in terms of t.
9) Find the value of i in permanent regime.

Exercise 3 (7 points)   Horizontal elastic pendulum.

An air puck (S) of mass m = 709 g is attached to the free end of a spring (R) of un-jointed turns, of negligible mass and of stiffness $k = 7\ N.m^{-1}$.

This puck, of a centre of mass G, may slide without friction on a horizontal rail (Doc 1). The figure shows a horizontal axis Ox of origin O. At equilibrium, G coincides with O.
At the instant $t_0 = 0$, (S) is displaced 3 cm from O in the positive direction and released without initial velocity.

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



(Doc 1)

1) The mechanical energy of the system ((S), (R), Earth) is conserved.

1-1) Determine the differential equation of the movement.

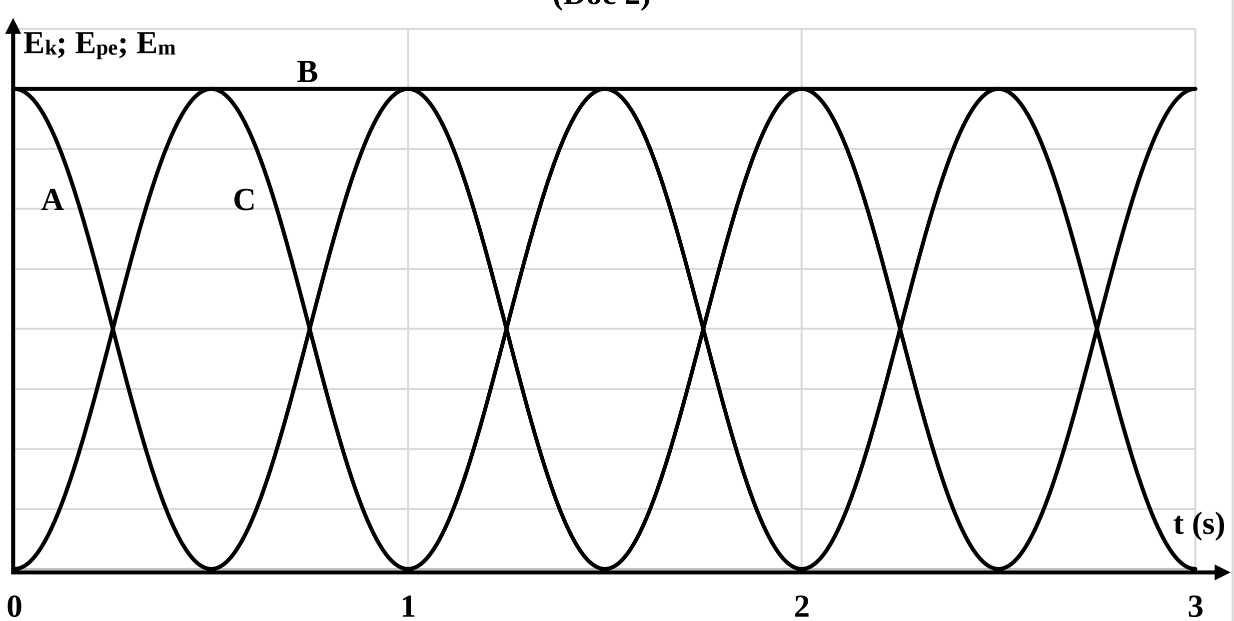
1-2) Verify that $x = x_m \cos\left(\sqrt{\frac{k}{m}}t + \varphi\right)$ is the solution of this differential equation for any value of the constants x_m and φ.

1-3) Calculate the values of x_m and φ.

2) Write down the formula that gives the expression of the natural period of the movement T_0 in terms of k and m then calculate its value.

3) The figure (Doc 2) below shows the curves of the variation of the kinetic energy E_k of (S), of the elastic potential energy E_{pe} of (R) and of the mechanical energy E_m of the system ((S), (R), Earth). Identify by the letters (A, B or C) the curves E_k, E_{pe} and E_m of the figure (Doc 2). Justify the answers.

(Doc 2)



4) The curves A and C are sine curves of a period T. Using the graph of figure (Doc 2) :

4-1) pick up the value of the period T;

4-2) compare its value to the natural period T_0 of the movement.

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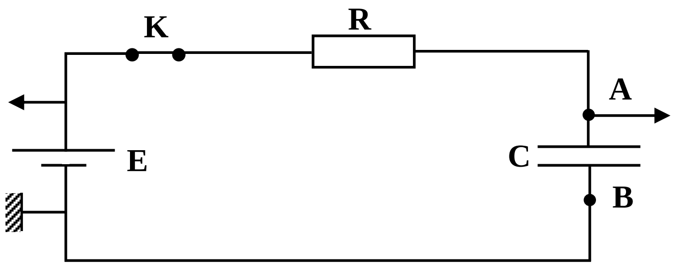
أسس التصحيح (تراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

Exercise 1 (6½ points) **Young's slits**

Question	Answer	Mark
1	Interference	¼
2	The light sources must be synchronous $\Rightarrow$ they must have the same frequency The light sources must be coherent $\Rightarrow$ they must keep a constant phase difference	¼ ¼ ¼ ¼
3	$\delta = \frac{ax}{D}$	¼
4	The interfringe distance is the distance between the centers of two consecutive fringes of the same nature	½
5	$i = \frac{\lambda D}{a}$ $\Rightarrow \; i = \frac{650\times10^{-9}\times 2}{10^{-3}} \Rightarrow i = 1.3\times10^{-3}\,m$	¼ ¼
6-1	$d_2 = d_1$ $\Rightarrow \delta = d_2 - d_1 = 0$ or $x = 0$ $\Rightarrow \; \delta = \frac{ax}{D} = 0$	¼ ¼ ¼ ¼
6-2	$\delta = 0$ so $\delta = k\lambda$ with $k = 0 \in \mathbf{Z}$ The interference is constructive and the fringe is bright	¼ ¼ ¼ ¼
7	$\frac{\delta}{\lambda} = \frac{2.275\times10^{-6}}{650\times10^{-9}} = 3.5$ so $\frac{\delta}{\lambda} = k + \frac{1}{2}$ with $k = 1 \in \mathbf{Z}$ The interference is destructive and the fringe is dark	¼ ¼ ¼ ¼
8	$\delta = \frac{ax_{O'}}{D} + \frac{ay}{d} = 0 \Rightarrow x_{O'} = -\frac{y.D}{d}$ $\Rightarrow x_{O'} = -\frac{10^{-2}\times 2}{10\times10^{-2}} = -0.2\,m$ The central fringe moves 0.2 m towards S_2	¼ ¼ ¼ ¼

Exercice 2 (6½ points) (RC) circuit.

Question	Answer	Mark
1		½
2	$i = \frac{dq}{dt}$	½
3	$q = Cu_C$ so $i = C\frac{du_C}{dt}$	½
4	Law of addition of voltages: $u_R + u_C = E$ Ohm's law: $u_R = Ri \Rightarrow u_R = RC\frac{du_C}{dt}$ The differential equation in terms of u_C is then: $RC\frac{du_C}{dt} + u_C = E$	 ½ ½
5	$u_C = D\left(1 - e^{-\frac{t}{\tau}}\right) \Rightarrow u_C = D - De^{-\frac{t}{\tau}}$ $\frac{du_C}{dt} = -D\left(-\frac{1}{\tau}\right)e^{-\frac{t}{\tau}} = \frac{D}{\tau}e^{-\frac{t}{\tau}}$ à $t = \infty$ $u_C = D\left(1 - e^{-\frac{\infty}{\tau}}\right) = D(1-0) = D$ and $u_C = E$ so $D = E$ replace u_C et $\frac{du_C}{dt}$ and D by their expressions in the differential equation. We get : $RC\frac{E}{\tau}e^{-\frac{t}{\tau}} + E - Ee^{-\frac{t}{\tau}} = E$ $RC\frac{E}{\tau}e^{-\frac{t}{\tau}} - Ee^{-\frac{t}{\tau}} = 0$ $Ee^{-\frac{t}{\tau}}\left(\frac{RC}{\tau} - 1\right) = 0$ $E \neq 0$ and $e^{-\frac{t}{\tau}} = 0$ is not true for any t ; so $\frac{RC}{\tau} - 1 = 0 \Rightarrow \frac{RC}{\tau} = 1 \Rightarrow$ $\tau = RC$	 ½ ½ ½

6	At $t = \tau$; $u_C = E\left(1 - e^{-\frac{\tau}{\tau}}\right) = E\left(1 - e^{-1}\right) \approx 0{,}63E$	½
7-1	At $t = \tau$; $u_C = 0.63E = 0.63 \times 8 = 5.04\ V \approx 5\ V$ from the graph we get : $\tau = 2$ s	½
7-2	$R = \frac{\tau}{C} \Rightarrow R = \frac{2}{100 \times 10^{-6}} = 2 \times 10^4\,\Omega$	½
8	$i = C\frac{du_C}{dt} = C\frac{E}{\tau}e^{-\frac{t}{\tau}} = C\frac{E}{RC}e^{-\frac{t}{\tau}} = \frac{E}{R}e^{-\frac{t}{\tau}}$	½
9	Permanent regime: $t = \infty$; $i = \frac{E}{R}e^{-\frac{\infty}{\tau}} = \frac{E}{R} \times 0 = 0A$	½

Exercise 3 (7 points) Horizontal elastic pendulum.

Question	Answer	Mark
1-1	$E_k = \frac{1}{2}mv^2 = \frac{1}{2}mx'^2 \Rightarrow \frac{d(E_k)}{dt} = \frac{1}{2}m(2x'x'') \Rightarrow \frac{d(E_k)}{dt} = mx'x''$ $E_{pe} = \frac{1}{2}kx^2 \Rightarrow \frac{d(E_{pe})}{dt} = \frac{1}{2}k(2xx') \Rightarrow \frac{d(E_{pe})}{dt} = kxx'$ $E_{pg} = \text{constant}$ because the rail is horizontal $\Rightarrow \frac{d(E_{pg})}{dt} = 0$ $E_m = E_k + E_{pe} + E_{pg}$ The mechanical energy of the system (puck, spring, Earth) is conserved E_m = constant $\Rightarrow \frac{d(E_m)}{dt} = 0 \Rightarrow \frac{d(E_k)}{dt} + \frac{d(E_{pe})}{dt} + \frac{d(E_{pg})}{dt} = 0$ $\Rightarrow mx'x'' + kxx' + 0 = 0 \Rightarrow mx'\left(x'' + \frac{k}{m}x\right) = 0$ The mass of the system $m \neq 0$ and $x' = 0$ for any t is rejected because this corresponds to equilibrium $\Rightarrow x'' + \frac{k}{m}x = 0$	½ ½ ½ ½
1-2	$x = x_m \cos\left(\sqrt{\frac{k}{m}}t + \varphi\right)$ $x' = -x_m\sqrt{\frac{k}{m}}\sin\left(\sqrt{\frac{k}{m}}t + \varphi\right)$ $x'' = -\frac{k}{m}x_m\cos\left(\sqrt{\frac{k}{m}}t + \varphi\right) = -\frac{k}{m}x$ replace x'' by its expression in the differential equation: $-\frac{k}{m}x + \frac{k}{m}x = 0$ is true for any x_m and φ.	 ½ ½

1-3	At t = 0 s ; $x' = -x_m\sqrt{\frac{k}{m}}\sin\left(\sqrt{\frac{k}{m}}t+\varphi\right)$ becomes $x'_0 = -x_m\sqrt{\frac{k}{m}}\sin\varphi$ $x'_0 = -x_m\sqrt{\frac{k}{m}}\sin\varphi = 0 \Rightarrow \sin\varphi = 0 \Rightarrow \varphi = 0$ rad or $\varphi = \pi$ rad At t = 0 s ; $x = x_m\cos\left(\sqrt{\frac{k}{m}}t+\varphi\right)$ becomes $x_0 = x_m\cos\varphi$ For $\varphi = 0$ rad : $x_0 = x_m = +3\,cm$ (acceptable because $x_m > 0$) For $\varphi = \pi$ rad : $x_0 = -x_m = +3\,cm \Rightarrow x_m = -3\,cm$ (rejected because $x_m < 0$)	½ ½
2	$T_0 = 2\pi\sqrt{\frac{m}{k}}$ $\Rightarrow T_0 = 2\pi\sqrt{\frac{0{,}709}{7}} = 2\,s$	½ ½
3	The curve A corresponds to E_{pe} because at t = 0 s, x ≠ 0 but $E_{pe} = \frac{1}{2}kx^2$ so $E_{pe}(0) \neq 0$ J The curve B corresponds to E_m because it has a constant value The curve C corresponds to E_k because at t = 0 s, v = 0 m/s but $E_k = \frac{1}{2}mv^2$ so $E_k(0) = 0$ J	½ ½ ½
4-1	From the graph we get : T = 1 s	¼
4-2	$T = T_0/2$	¼