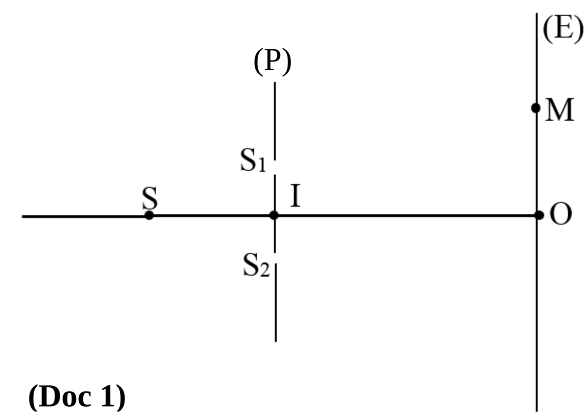
المادة: الفيزياء الشهادة: الثانوية العامّة الفرع: علوم الحياة نموذج رقم 1 المدّة: ساعتان	الهيئة الأكاديميّة المشتركة قسم: العلوم	المركز التربوي للبحوث والإنماء

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

This test includes three mandatory exercises. The use of non-programmable calculators is allowed.

Exercise 1 (6½ points) Young's slits

Consider the Young's slits device (Doc 1) 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 air of the monochromatic light is $\lambda = 650$ nm.



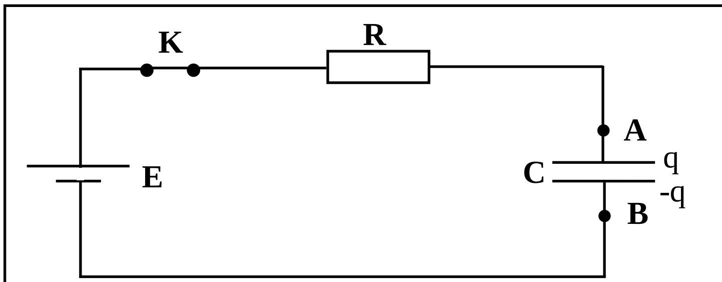
(Doc 1)

1) A pattern is observed on the screen (E). Indicate the name of the correspondent phenomenon.
2) State the conditions ensured by S_1 and S_2 in order to obtain this pattern.
3) Consider a point M of the pattern observed on the screen (E) such as $\overline{OM} = x$. Take $d_1 = S_1M$ and $d_2 = S_2M$. Write the relation that gives the optical path difference $\delta = d_2 - d_1$ at M 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 optical path difference δ at O.
  6-2) Specify whether this fringe is bright or dark.
7) Let N be the centre of a fringe where $\delta = 2{,}275$ µm. Specify whether 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 to the side of S_1. The new optical path difference is then: $\delta' = \frac{ax}{D} + \frac{ay}{d}$. Specify the direction of the displacement of the centre of the central fringe (to the side of S_1 or S_2) and calculate the displacement.

Exercise 2 (6½ points) (RC) series circuit

The electric circuit of the document (Doc 2) is formed of:

- A generator delivering 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.



(Doc 2)

At the instant $t_0 = 0$, we close the switch K.
At an instant t, the capacitor is charged by q and the circuit carries a current i.

1) Redraw the figure of the document (Doc 2) and show the connections of an oscilloscope that allows to display 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 that describes the variation of u_C as a function of time**.**

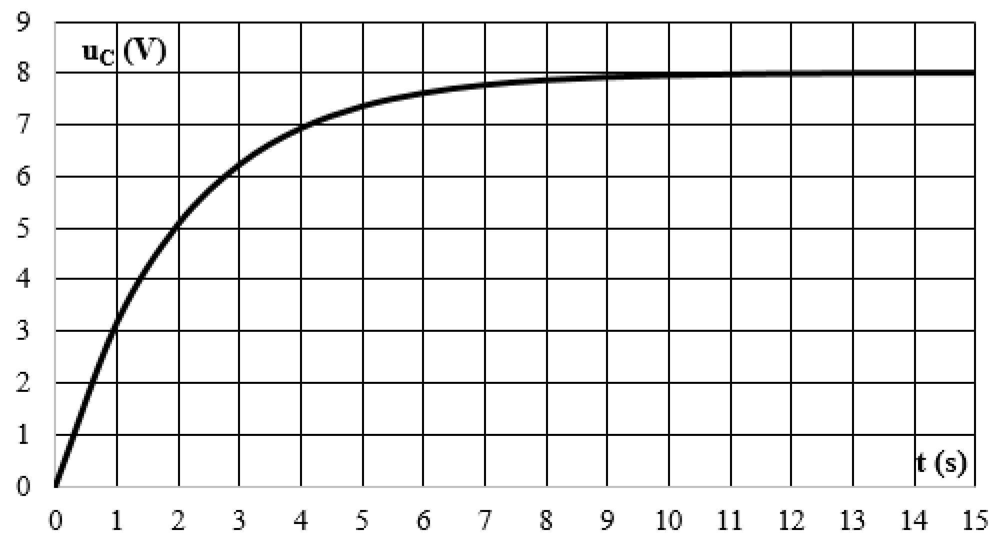
5) The solution of this differential equation is: $u_C = D\left(1 - e^{-\frac{t}{\tau}}\right)$. Determine the expressions of the constants D and τ in terms of E, R and C.

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

7) Referring to the graph of $u_C = f(t)$ of the document (Doc 3) below:

7-1) Determine the value of τ.

7-2) Deduce the value of the resistance R.



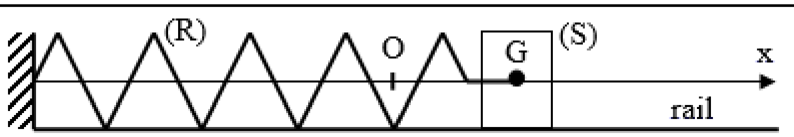
(Doc 3)

8) Determine the expression of the current i as a function of time t.

9) Deduce the value of the current i in steady state.

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 centre of mass G, may slide without friction on a horizontal rail (Doc 4). The document (Doc 4) shows a horizontal axis Ox of origin O. At equilibrium, G coincides with O.
(S) is shifted 3 cm from O ($\overrightarrow{OG_0} = x_0\vec{i} = 3\,\vec{i}$) in the positive direction and released without velocity at the instant $t_0 = 0$.
At an instant t, x is the abscissa of G and $v = \frac{dx}{dt}$ is the algebraic measure of its velocity.



(Doc 4)

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

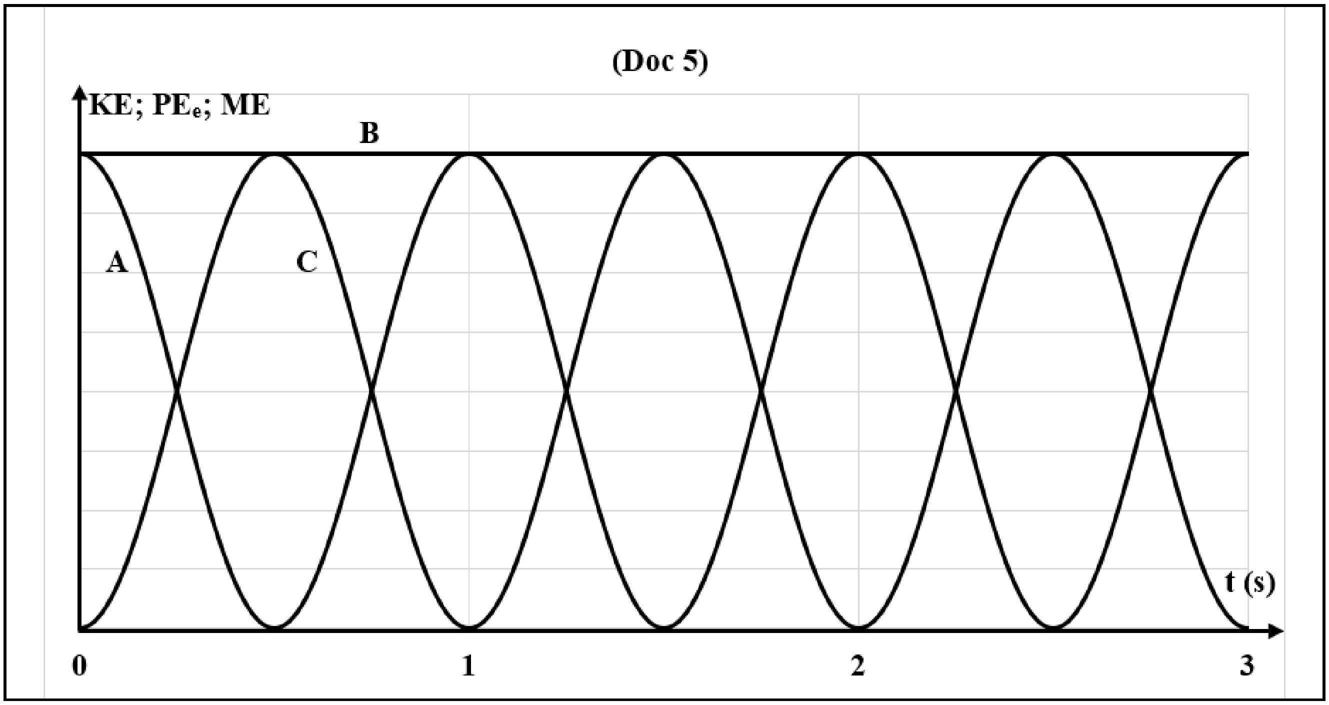
1-1) Determine the second order differential equation in x.

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

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

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

3) The document (Doc 5) below shows the curves giving the variations of the kinetic energy KE of (S), of the elastic potential energy PE_e of (R) and of the mechanical energy ME of the system ((S), (R), Earth). Identify the curves KE, PE_e and ME of the document (Doc 5).



4) Each of the curves A and C is sinusoidal of a period T. Referring to the graph of document (Doc 5) :

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

4-2) Compare its value to the natural period T_0 of the motion.

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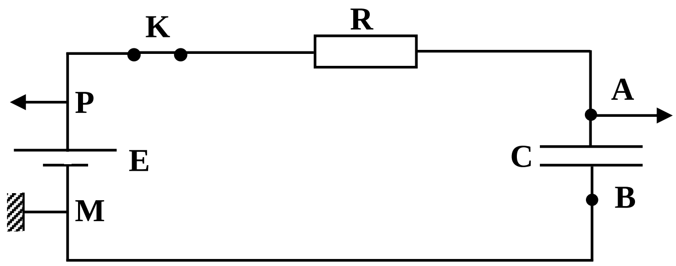
أسس التصحيح (تراعي تعليق الدروس والتوصيف المعدّل للعام الدراسي 2016-2017 وحتى صدور المناهج المطوّرة)

Exercise 1 (6½ points) Young's slits

Question	Answer	Mark
1	Interference.	¼
2	The light sources must be synchronous (they must have the same frequency) and coherent (they must keep a constant phase difference).	¼ ¼
3	$\delta = \frac{ax}{D}$	½
4	The interfringe distance is the distance between the centers of two consecutive fringes of the same nature.	½
5	$i = \frac{\lambda D}{a}$ $\Rightarrow \quad i = \frac{650\times10^{-9}\times2}{10^{-3}} \quad \Rightarrow \quad i = 1.3\times10^{-3}\,m$	¼ ½
6-1	$d_2 = d_1$ $\Rightarrow \quad \delta = d_2 - d_1 = 0$ or $x = 0$ $\Rightarrow \quad \delta = \frac{ax}{D} = 0$	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	$\delta = \frac{ax_{O'}}{D} + \frac{ay}{d} = 0 \quad \Rightarrow \quad x_{O'} = -\frac{y.D}{d}$ $\Rightarrow \quad x_{O'} = -\frac{10^{-2}\times2}{10\times10^{-2}} = -0.2\,m$ The central fringe moves 0.2 m towards S_2	¼ ¼ ¼ ¼

Exercise 2 (6½ points) (RC) series 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: $u_{PM} = u_{PA} + u_{AB} + u_{BM}$ $u_{PA} = u_R$; $u_{AB} = u_C$ and $u_{BM} = 0$ So : $u_R + u_C = E \quad \forall t$ Ohm's law: $u_R = Ri \quad \Rightarrow \quad u_R = RC\frac{du_C}{dt}$ The differential equation in terms of u_C is then: $RC\frac{du_C}{dt} + u_C = E$	½ ½
5	$u_C = D\left(1 - e^{-\frac{t}{\tau}}\right) \quad \Rightarrow \quad u_C = D - De^{-\frac{t}{\tau}}$ $\frac{du_C}{dt} = -D\left(-\frac{1}{\tau}\right)e^{-\frac{t}{\tau}} = \frac{D}{\tau}e^{-\frac{t}{\tau}}$ Replace u_C and $\frac{du_C}{dt}$ by their expressions in the differential equation. We get: $RC\frac{D}{\tau}e^{-\frac{t}{\tau}} + D - De^{-\frac{t}{\tau}} = E \quad \forall t$ $D(\frac{RC}{\tau} - 1)e^{-\frac{t}{\tau}} + D - E = 0 \quad \forall t$ Identifying, we get: D-E=0 $\Rightarrow$ D=E $\left(\frac{RC}{\tau} - 1\right) = 0 \quad \Rightarrow \quad \tau = RC$	½ ½ ½
6	At t = τ ; $u_C = E\left(1 - e^{-\frac{\tau}{\tau}}\right) = E\left(1 - e^{-1}\right) \approx 0{,}63E$	½
7-1	At t = τ ; u_C = 0.63E = 0.63 x 8 = 5.04 V ≈ 5 V from the graph we get : τ = 2 s	½
7-2	$R = \frac{\tau}{C} \quad \Rightarrow \quad R = \frac{2}{100 \times 10^{-6}} = 2 \times 10^4 \Omega$	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: $t = \infty$; $i = \frac{E}{R}e^{-\frac{\infty}{\tau}} = \frac{E}{R}\times 0 = 0$ A	½

Exercise 3 (7 points) Horizontal elastic pendulum

Question	Answer	Mark
1-1	PE_g = constant because the rail is horizontal $\Rightarrow \frac{dPE_g}{dt} = 0$ $ME = KE + PE_e + PE_g$ The mechanical energy of the system (puck, spring, Earth) is conserved $ME = ½mv^2 + ½kx^2 + PE_g$ = constant $\forall t \Rightarrow \frac{d(ME)}{dt} = 0 \quad \forall t$ $\Rightarrow \quad mx'x'' + kxx' + 0 = 0 \quad \forall t \quad \Rightarrow \quad mx'\left(x'' + \frac{k}{m}x\right) = 0 \quad \forall t$ The product of the two quantities is always nil. But mx' is not always nil, we get: $x'' + \frac{k}{m}x = 0 \quad \forall t$	½ ½ ½ ½
1-2	$x = x_m \cos\left(\sqrt{\frac{k}{m}}t + \varphi\right) \Rightarrow$ $x' = -x_m\sqrt{\frac{k}{m}}\sin\left(\sqrt{\frac{k}{m}}t + \varphi\right) \Rightarrow x'' = -\frac{k}{m}x_m\cos\left(\sqrt{\frac{k}{m}}t + \varphi\right) = -\frac{k}{m}x$ Replace x'' by its expression in the differential equation: The relation $-\frac{k}{m}x + \frac{k}{m}x = 0$ is true.	½ ½
1-3	At $t_0 = 0$ s ; $v_0 = x'_0 = -x_m\sqrt{\frac{k}{m}}\sin\varphi = 0 \Rightarrow \sin\varphi = 0 \Rightarrow \varphi = 0$ or $\varphi = \pi$ rd At t = 0 s ; $x_0 = x_m\cos\varphi > 0$ For $\varphi = 0$ rd : $x_0 = x_m = +3$ cm (acceptable because $x_m > 0$) For $\varphi = \pi$ rd : $x_0 = -x_m = +3$ cm $\Rightarrow x_m = -3$ cm (rejected because x_m is always positive)	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 PE_e because at $t_0 = 0$ s, $x_0 \neq 0$ but $PE_e = \frac{1}{2}kx^2$ so $PE_e(0) \neq 0$ J The curve B corresponds to ME because it has a constant value The curve C corresponds to KE because at t = 0 s, v = 0 m/s but $KE = \frac{1}{2}mv^2$ so KE(0) = 0 J	½ ½ ½
4-1	From the graph we get : T = 1 s	¼
4-2	$T = T_0/2$	¼