

المادة: الفيزياء الشهادة: الثانوية العامة الفرع: علوم الحياة نموذج رقم 1 المدة: ساعتان	الهيئة الأكاديمية المشتركة قسم: العلوم	 المركز التربوي للبحوث والإنماء
--	---	---

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

This test is made up of three obligatory exercises in four pages.

The use of non-programmable calculators is allowed.

Exercise 1 (6½ points)

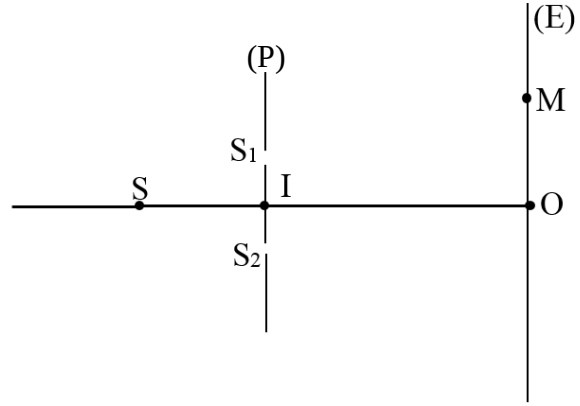
Young's slits

Consider the Young's slits device made up of two very thin and horizontal slits S_1 and S_2 separated by a distance $a = 1 \text{ mm}$, 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 $D = 2 \text{ m}$ 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 $\lambda = 650 \text{ nm}$.



- 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 $\delta = 2,275 \mu\text{m}$. Specify if this fringe is bright or dark.
- 8) S is at a distance $d = 10 \text{ cm}$ from I. We displace S vertically of a distance $y = 1 \text{ cm}$ 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.

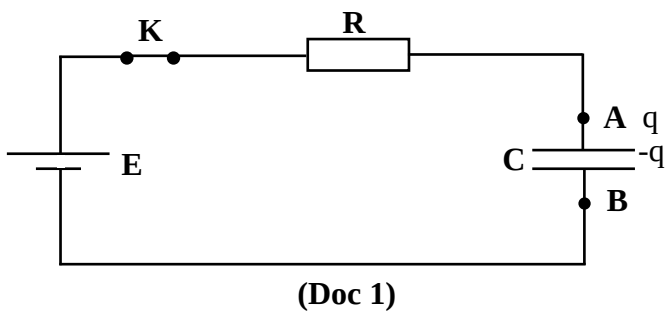
The electric circuit of the figure (Doc 1) is composed of:

- a generator supplying across its terminals a constant voltage $E = 8 \text{ V}$;
- a resistor of unknown resistance R ;
- a capacitor of capacitance $C = 100 \mu\text{F}$, initially discharged;
- a switch K.

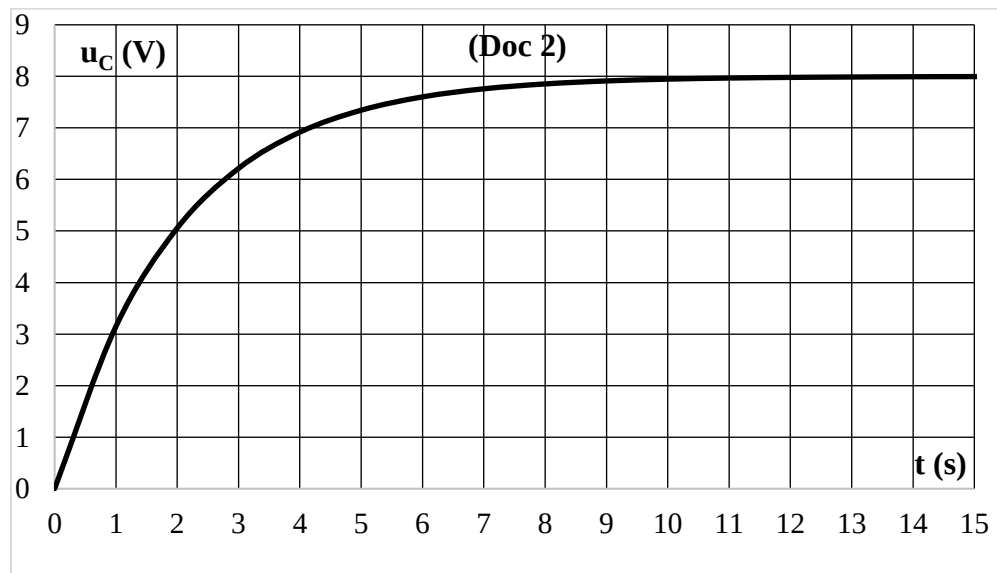
At the instant $t = 0$, we close the switch K.

At an instant t , the 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 .



- 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.

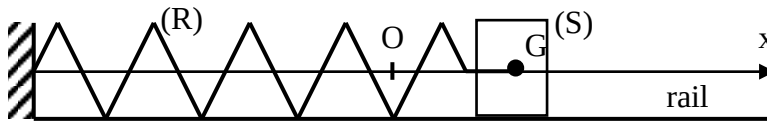
Exercise 3 (7 points)**Horizontal elastic pendulum.**

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

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.

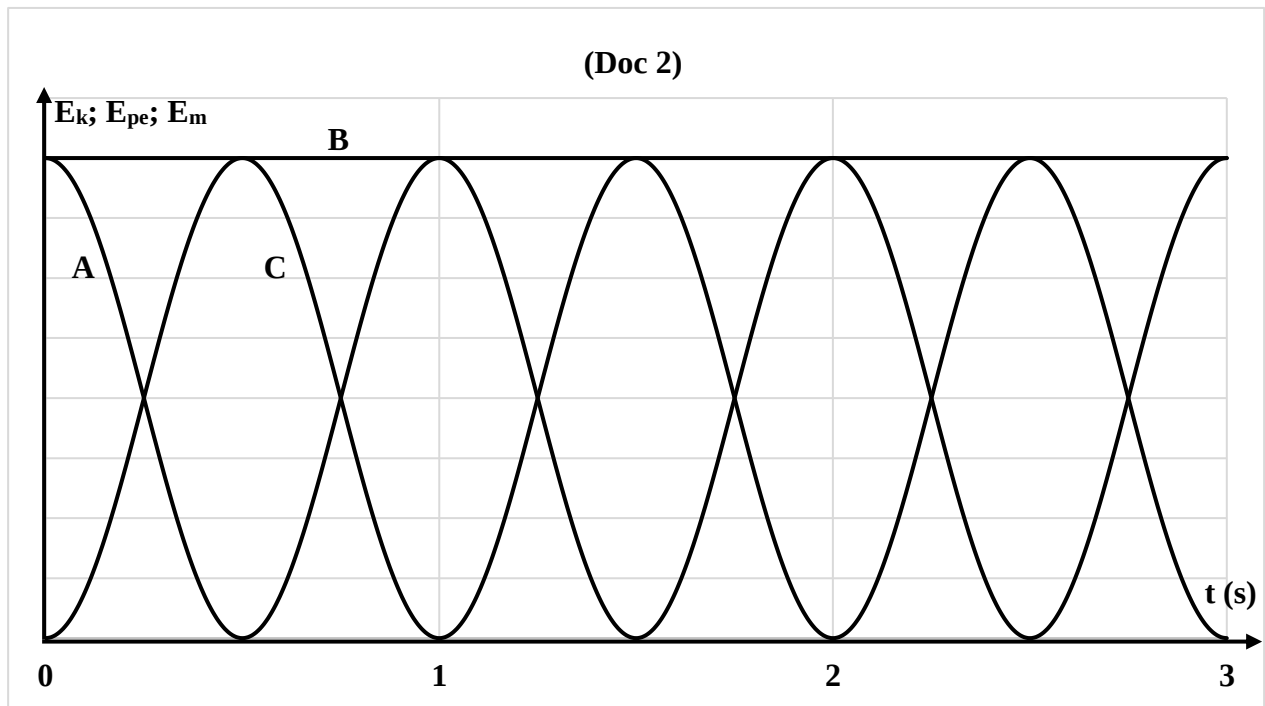
At the instant $t_0 = 0$, (S) is displaced 3 cm from O in the positive direction and released without initial velocity.

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.



- 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.

المادة: الفيزياء الشهادة: الثانوية العامة الفرع: علوم الحياة نموذج رقم 1 المدة: ساعتان	الهيئة الأكاديمية المشتركة قسم: العلوم	 المركز التربوي للبحوث والإنماء
--	---	---

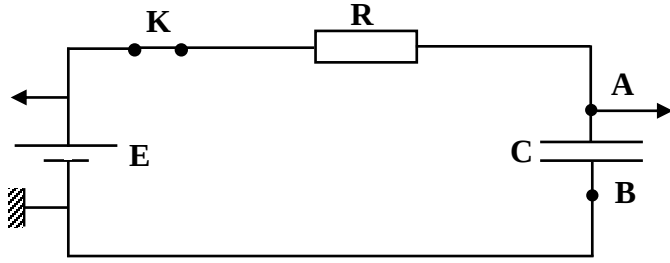
أسس التصحيح (تراعي تعليق الدروس والتوصيف المعدل للعام الدراسي 2016-2017 وحتى صدور المناهج المطورة)

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 The light sources must be coherent ⇒ 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	$i = \frac{\lambda D}{a}$ $\Rightarrow i = \frac{650 \times 10^{-9} \times 2}{10^{-3}} \Rightarrow i = 1.3 \times 10^{-3} \text{ m}$	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	$\frac{\delta}{\lambda} = \frac{2.275 \times 10^{-6}}{650 \times 10^{-9}} = 3.5$ 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	$\delta = \frac{ax_{O'}}{D} + \frac{ay}{d} = 0 \Rightarrow x_{O'} = -\frac{y.D}{d}$ $\Rightarrow x_{O'} = -\frac{10^{-2} \times 2}{10 \times 10^{-2}} = -0.2 \text{ m}$ The central fringe moves $2 \times 10^{-3} \text{ m}$ towards S_2	¼ ¼ ¼ ¼

Exercise 2 (6½ points)
(RC) circuit.

Question	Answer	Mark
1		½
2	$i = \frac{dq}{dt}$	½
3	$q = Cu_C \text{ so } i = C \frac{du_C}{dt}$	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	$u_C = D \left(1 - e^{-\frac{t}{\tau}} \right) \Rightarrow u_C = D - D e^{-\frac{t}{\tau}}$ $\frac{du_C}{dt} = -D \left(-\frac{1}{\tau} \right) e^{-\frac{t}{\tau}} = \frac{D}{\tau} e^{-\frac{t}{\tau}}$ à $t = \infty \quad u_C = D \left(1 - e^{-\frac{\infty}{\tau}} \right) = D(1 - 0) = D \quad \text{and} \quad u_C = E \quad \text{so} \quad D = E$ replace u_C et $\frac{du_C}{dt}$ and D by their expressions in the differential equation. We get : $RC \frac{E}{\tau} e^{-\frac{t}{\tau}} + E - E e^{-\frac{t}{\tau}} = E$ $RC \frac{E}{\tau} e^{-\frac{t}{\tau}} - E e^{-\frac{t}{\tau}} = 0$ $E e^{-\frac{t}{\tau}} \left(\frac{RC}{\tau} - 1 \right) = 0$ $E \neq 0 \quad \text{and} \quad e^{-\frac{t}{\tau}} = 0 \text{ is not true for any } t; \quad \text{so} \quad \frac{RC}{\tau} - 1 = 0 \Rightarrow \frac{RC}{\tau} = 1 \Rightarrow$ $\tau = RC$	½ ½ ½

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

Exercise 3 (7 points)

Horizontal elastic pendulum.

Question	Answer	Mark
1-1	$E_k = \frac{1}{2}mv^2 = \frac{1}{2}mx'^2 \Rightarrow \frac{d(E_k)}{dt} = \frac{1}{2}m(2x'x'') \Rightarrow \frac{d(E_k)}{dt} = mx'x''$	$\frac{1}{2}$
	$E_{pe} = \frac{1}{2}kx^2 \Rightarrow \frac{d(E_{pe})}{dt} = \frac{1}{2}k(2xx') \Rightarrow \frac{d(E_{pe})}{dt} = kxx'$	$\frac{1}{2}$
	$E_{pg} = \text{constant}$ 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 $E_m = \text{constant} \Rightarrow \frac{d(E_m)}{dt} = 0 \Rightarrow \frac{d(E_k)}{dt} + \frac{d(E_{pe})}{dt} + \frac{d(E_{pg})}{dt} = 0$ $\Rightarrow mx'x'' + kxx' + 0 = 0 \Rightarrow mx' \left(x'' + \frac{k}{m}x \right) = 0$	$\frac{1}{2}$
1-2	The mass of the system $m \neq 0$ and $x' = 0$ for any t is rejected because this corresponds to equilibrium $\Rightarrow x'' + \frac{k}{m}x = 0$	$\frac{1}{2}$
	$x = x_m \cos \left(\sqrt{\frac{k}{m}}t + \varphi \right)$ $x' = -x_m \sqrt{\frac{k}{m}} \sin \left(\sqrt{\frac{k}{m}}t + \varphi \right)$ $x'' = -\frac{k}{m}x_m \cos \left(\sqrt{\frac{k}{m}}t + \varphi \right) = -\frac{k}{m}x$ 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 .	$\frac{1}{2}$

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