| وزارة التربية والتعليم العالي<br>المديرية العامة للتربية<br>دائرة الامتحانات | امتحانات الشهادة الثانوية العامة<br>الفرع : علوم الحياة | الدورة الإستثنائية للعام<br>2011 |
|---|---|---|
| | مسابقة في مادة الفيزياء<br>المدة ساعتان | الاسم:<br>الرقم: |

**This exam is formed of three exercises in three pages.**
**The use of a non-programmable calculator is allowed**

## *First Exercise* (6 ½ points)

### *Determination of the inductance of a coil*

In order to determine the inductance L of a coil of negligible resistance, we connect this coil in series with a resistor of resistance R = 10 Ω across the terminals of a generator G (Fig. 1). The generator G delivers an alternating sinusoidal voltage $u_{AD} = u_G = U_m \cos\omega t$ ($u_G$ in V, t in s).
The circuit thus carries a current i.

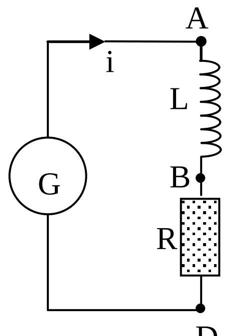



**Fig.1**

***1)*** Redraw a diagram of figure (1), showing on it the connections of an oscilloscope so as to display the voltage $u_G$ across the terminals of the generator and the voltage $u_R = u_{BD}$ across the terminals of the resistor.

***2)*** Which of these two voltages represents the image of i ?
Justify your answer

***3)*** In figure 2, the waveform (1) represents the variation of $u_G$ as a function of time.
- Horizontal sensitivity: 5 ms/div.
- Vertical sensitivity on both channels: 1 V/div.

***a)*** Specify, with justification, which of the waveforms, (1) or (2), leads the other.

***b)*** Determine:
***i.*** The phase difference between these two waveforms.
***ii.*** The angular frequency ω.
***iii.*** The maximum value $U_m$ of the voltage across G.
***iv.*** The amplitude $I_m$ of i.

***c)*** Write down the expression of i as a function of time t.

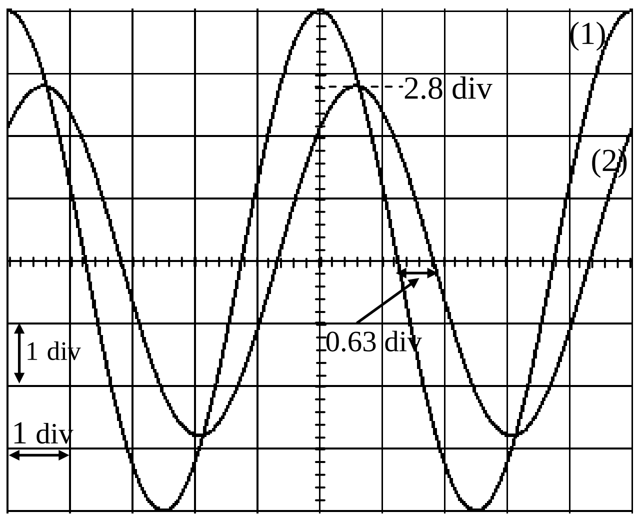



**Fig.2**

***4)*** Determine the voltage $u_{AB} = u_L$ across the terminals of the coil as a function of L and t.

***5)*** Determine the value of L by applying the law of addition of voltages and by giving t a particular value.

***Second Exercise*** ***(7 points)***

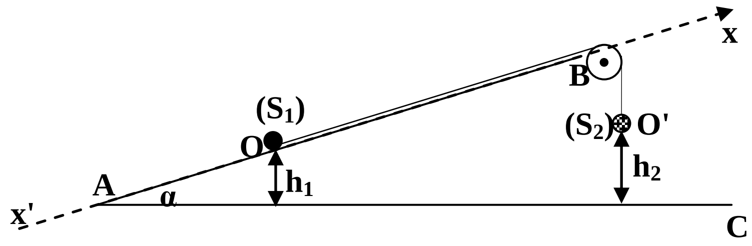
## ***Acceleration of a particle***

The object of this exercise is to determine the expression of the magnitude of the acceleration of a particle using two methods. The apparatus used is formed of two particles $(S_1)$ and $(S_2)$ of respective masses $m_1$ and $m_2$, fixed at the extremities of an inextensible string passing over the groove of a pulley. $(S_1)$, $(S_2)$, the string and the pulley form a mechanical system (S).

The string and the pulley have negligible mass.

$(S_1)$ may move on the line of greatest slope AB of an inclined plane that makes an angle α with the horizontal AC and $(S_2)$ hangs vertically.

At rest, $(S_1)$ is found at point O at a height $h_1$ above AC and $(S_2)$ is found at O' at a height $h_2$ (adjacent figure).




At the instant $t_0 = 0$, we release the system (S) from rest. $(S_1)$ ascends on AB and $(S_2)$ descends vertically.

At an instant t, the position of $(S_1)$ is defined by its abscissa $x = \overline{OS_1}$ on an axis x'Ox confounded with AB, directed from A to B.

Take the horizontal plane containing AC as a gravitational potential energy reference.

Neglect all the forces of friction.

***1) Energetic method***

- ***a)*** Write down, at the instant $t_0 = 0$, the expression of the mechanical energy of the system [(S), Earth] in terms of $m_1$, $m_2$, $h_1$, $h_2$ and g.
- ***b)*** At the instant t, the abscissa of $(S_1)$ is x and the algebraic value of its velocity is v. Determine, at that instant t, the expression of the mechanical energy of the system [(S), Earth] in terms of $m_1$, $m_2$, $h_1$, $h_2$, x, v, α and g.
- ***c)*** Applying the principle of conservation of mechanical energy, show that :
  $$v^2 = \frac{2(m_2 - m_1 \sin\alpha)gx}{(m_1 + m_2)}.$$
- ***d)*** Deduce the expression of the value a of the acceleration of $(S_1)$.

***2) Dynamical method***

- ***a)*** Redraw a diagram of the figure and show, on it, the external forces acting on $(S_1)$ and on $(S_2)$. (The tension in the string acting on $(S_1)$ is denoted by $\vec{T}_1$ of magnitude $T_1$ and that acting on $(S_2)$ is denoted by $\vec{T}_2$ of magnitude $T_2$).
- ***b)*** Applying the theorem of the center of mass $\Sigma\vec{F}_{ext} = m\vec{a}$ ,on each particle, determine the expressions of $T_1$ and $T_2$ in terms of $m_1$ , $m_2$ , g , α and a .
- ***c)*** Knowing that $T_1 = T_2$, deduce the expression of a.

***Third Exercise*** ***(6 ½ points)***

## ***Provoked Nuclear Reactions***

The object of this exercise is to compare the energy liberated per nucleon in a nuclear fission with that liberated in a nuclear fusion.

***Given:***

| Symbol | ${}_{0}^{1}n$ | ${}_{1}^{2}H$ | ${}_{1}^{3}H$ | ${}_{2}^{4}He$ | ${}_{92}^{235}U$ | ${}_{Z}^{94}Sr$ | ${}_{54}^{A}Xe$ |
|---|---|---|---|---|---|---|---|
| Mass in u | 1.00866 | 2.01355 | 3.01550 | 4.0015 | 234.9942 | 93.8945 | 138.8892 |

1u = 931.5 MeV/$c^2$

### *A – Nuclear fission*

The fission of uranium 235 is used to produce energy.

***1)*** The fission of one uranium 235 nucleus takes place by bombarding this nucleus by a slow (thermal) neutron of kinetic energy around 0.025 eV .The equation of this reaction is written as :

$${}_{92}^{235}U + {}_{0}^{1}n \rightarrow {}_{Z}^{94}Sr + {}_{54}^{A}Xe + 3{}_{0}^{1}n$$

***a)*** Calculate A and Z specifying the laws used.
***b)*** Show that the energy E liberated by the fission of one uranium nucleus is 179.947 MeV.
***c)*** ***i)*** The number of nucleons participating in this reaction is 236. Why?
***ii)*** Calculate then $E_1$, the energy liberated per nucleon participating in this fission reaction.

***2)*** Each of the obtained neutrons has an average kinetic energy $E_0 = \frac{E}{100}$.

***a)*** In this case, the obtained neutrons do not, in general, provoke fission. Why?
***b)*** What then should be done in order to obtain a fission reaction?

### *B – Nuclear fusion*

Nowadays, many researches are performed in order to produce energy by nuclear fusion. The most accessible is the reaction between a deuterium nucleus ${}_{1}^{2}H$ and a tritium nucleus ${}_{1}^{3}H$ .

***1)*** The deuterium and the tritium are two isotopes of hydrogen. Write down the symbol of the third isotope of hydrogen.
***2)*** Write down the fusion reaction of a deuterium nucleus with a tritium nucleus knowing that this reaction liberates a neutron and a nucleus ${}_{Z}^{A}X$ . Calculate Z and A and give the name of the nucleus ${}_{Z}^{A}X$ .
***3)*** Show that the energy liberated by this reaction is E' =17.596 MeV.
***4)*** Calculate $E'_1$ the energy liberated per nucleon participating in this reaction.

### *C – Conclusion*

Compare $E_1$ and $E'_1$ and conclude.

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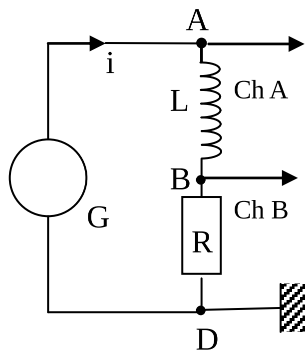
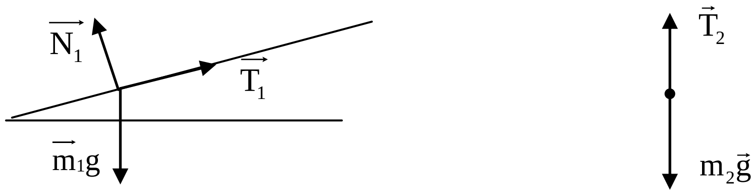
|---|---|---|
| الاسم:<br>الرقم: | مسابقة في مادة الفيزياء<br>المدة ساعتان | مشروع معيار التصحيح |

## First exercise (6 ½ points)

| Part of the Q. | Answer | Mark |
|---|---|---|
| 1 |  | ½ |
| 2 | $u_R = Ri$, $u_R$ is proportional to i. | ½ |
| 3-a | $u_1$ becomes zero before $u_2$, thus $u_1 = u_G$ leads i ($u_2 = u_R$ represents i). | ½ |
| 3-b-i | T ↔ 5 div ↔ 2π rad<br>0.63 div ↔ φ ⇒ $\varphi = 2\pi \times \frac{0.63}{5} = 0.79$ rd | ¾ |
| 3-b-ii | T = 5 (div)×5 ms/div = 25 ms<br>$\omega = \frac{2\pi}{T} = 251.3$ rad/s | ½ |
| 3-b-iii | Um = 4 (div)× 1 V/div = 4 V | ½ |
| 3-b-iv | $U_{Rm} = 2.8\times1 = 2.8$ V<br>$\Rightarrow I_m = \frac{U_{Rm}}{R} = \frac{2.8}{10} = 0.28$ A | ¾ |
| 3-c | i lags $u_G$ by 0.79 rad;<br>$i = I_m \cos(\omega t - 0.79)$<br>$i = 0.28 \cos(80\pi t - 0.79)$ | ½ |
| 4 | $u_L = L\frac{di}{dt} = -70.37L \sin(80\pi t - 0.79)$ | **1** |
| 5 | $u_G = u_R + u_L = Ri + u_L$<br>$4 \cos(80\pi t) = 2.8 \cos(80\pi t - 0.79) - 70.37L \sin(80\pi t - 0.79)$<br>For t = 0 ; L = 0.04 H = 40 mH. | **1** |

## Second exercise (7 points)

| Part of the Q | Answer | Mark |
|---|---|---|
| 1.a | $M.E = K.E_1 + P.E_{g1} + K.E_2 + P.E_{g2} = 0 + m_1gh_1 + 0 + m_2gh_2$ | ½ |
| 1.b | $M.E = KE_1 + P.E_{g1} + K.E_2 + P.E_{g2}$<br>$M.E = \frac{1}{2} m_1v^2 + m_1g\,(h_1 + x\sin\alpha) + \frac{1}{2} m_2v^2 + m_2g\,(h_2 - x)$ | 1 |
| 1.c | $\frac{1}{2} m_1v^2 + m_1g\,(h_1 + x\sin\alpha) + \frac{1}{2} m_2v^2 + m_2g\,(h_2 - x) = m_1gh_1 + m_2gh_2$<br>$\Rightarrow \frac{1}{2}(m_1 + m_2)\,v^2 = (m_2 - m_1\sin\alpha)\,gx \Rightarrow v^2 = \frac{2(m_2 - m_1\sin\alpha)gx}{(m_1 + m_2)}$. | ¾ |
| 1.d | Derive the expression of $v^2$ w.r.t time , we get:<br>$2va = \frac{2(m_2 - m_1\sin\alpha)g}{(m_1 + m_2)} v \Rightarrow a = \frac{(m_2 - m_1\sin\alpha)g}{(m_1 + m_2)}$. | 1 |
| A.2.a | <br> | 1¼ |
| 2.b | The relation $\Sigma\vec{F}_{ext} = m_1\vec{a_1}$ applied on $S_1$ gives:<br>$m_1\vec{g} + \vec{N_1} + \vec{T_1} = m_1\vec{a}_1$ ….. (1)<br>Projecting (1) on the axis $\overrightarrow{ox}$ we get : $-m_1g\sin\alpha + T_1 = m_1a_1 \Rightarrow$<br>$T_1 = m_1g\sin\alpha + m_1a$ (with $a_1 = a_2 = a$).<br><br>The relation $\Sigma\vec{F}_{ext} = m_2\vec{a_2}$ applied on $S_2$ gives :<br>$m_2\vec{g} + \vec{T_2} = m_2\vec{a}_2$ …. (2)<br>Projecting (2) on the vertically downward axis we get:<br>$m_2g - T_2 = m_2a_2 \Rightarrow T_2 = m_2g - m_2a$. | 2 |
| 2.c | The relation $T_1 = T_2$ gives: $m_1g\sin\alpha + m_1a = m_2g - m_2a$<br>$\Rightarrow a = \left(\frac{m_2 - m_1\sin\alpha}{m_1 + m_2}\right)g$. | ½ |

## Third exercise (6 ½ points)

| Part of the Q | Answer | Mark |
|---|---|---|
| A.1.a | Conservation of nucleons number: 235 + 1 = 94 + A +3 then A = 139<br>Conservation of charge number: 92 = Z + 54 then Z = 38 | **1** |
| A.1.b | $E = \Delta mc^2$<br>$= (234.9942+1.00866 - 93.8945 - 138.8892 - 3\times1.00866)\times931.5$<br>$\Rightarrow$ Energy = 179.947 MeV | **1** |
| A.1.c.i | We have 235+1 = 236 nucleons | **¼** |
| A.1.c.ii | $E_1 = \frac{179.947}{236} = 0.76$ MeV/nucleon | **¼** |
| A.2.a | $E_0 = \frac{179.947}{100} = 1.79947$ MeV; which is much greater than 0.025 eV | **½** |
| A.2.b | They should be slowed down, | **¼** |
| B.1 | ${}_1^1H$ | **¼** |
| B.2 | ${}_1^2H + {}_1^3H \rightarrow {}_Z^AX + {}_0^1n$<br>2+3 = A + 1 then A = 4 1+1 = Z then Z = 2<br>The helium nucleus ${}_2^4He$ | **1** |
| B.3 | $E' = \Delta mc^2 = (2.01355+3.0155 - 4.0015 - 1.00866)\times 931.5 = 17.596$ MeV | **1** |
| B.4 | We have 2 + 3 = 5 nucleons $\Rightarrow E_1' = \frac{17.596}{5} = 3.5912$ MeV/nucleon | **½** |
| C | $E_1'$ is greater than $E_1$ ; fusion is more efficient. | **½** |