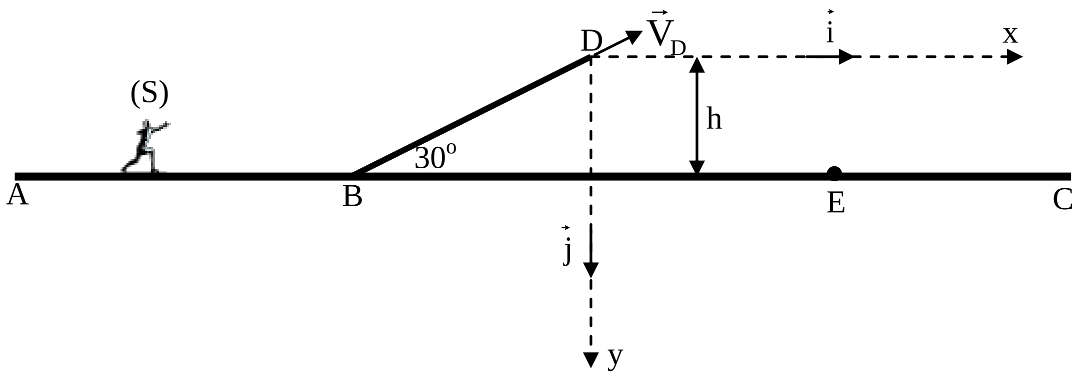
الدورة الإستثنائية للعام 2012	امتحانات الشهادة الثانوية العامة الفرع : علوم الحياة	وزارة التربية والتعليم العالي المديرية العامة للتربية دائرة الامتحانات
الاسم: الرقم:	مسابقة في مادة الفيزياء المدة ساعتان	

<u>This exam is formed of three exercises in three pages numbered from 1 to 3.</u>
<u>The use of a non-programmable calculator is recommended.</u>

<u>First exercise</u>: (7 points)

Study of the motion of a skier

A skier (S), of mass m = 80 kg, is pulled by a boat using a rope parallel to the surface of water. He starts from point A at the instant $t_0 = 0$ without initial velocity.
The skier passes point B at the instant t = 60 s with a speed $V_B = 6$ m/s, then he releases the rope. He continues his motion along a board BD inclined by an angle of 30^o with respect to the horizontal surface of water. Suppose that during the passage from AB to BD the speed at point B does not change.
The skier arrives point D, situated at an altitude h = 1.6 m from the water surface, with a velocity $\vec{V}_D$, then he leaves the board at point D to hit the water surface at point E (see figure below).



Given:

- ❖ the skier is considered as a particle;
- ❖ on the path AB, the force of traction $\vec{F}$ exerted by the rope on the skier has a constant magnitude F and the whole forces of friction are equivalent to a single force $\vec{f}$ opposite to the displacement, of magnitude f = 100 N;
- ❖ friction is negligible along the path BDE;
- ❖ after leaving point D the motion of the skier takes place in the vertical plane Dxy containing $\vec{V}_D$;
- ❖ the horizontal plane passing through AB is the reference level of the gravitational potential energy;
- ❖ g = 10 m/s^2.

A – Motion of the skier between A and B

1) What are the external forces acting on (S) along the path AB? Draw, not to scale, a diagram of these forces.

2) Applying Newton's second law $\frac{d\vec{P}}{dt} = \Sigma\vec{F}_{ext}$ on the skier, between the points A and B, express the acceleration a of the motion of the skier in terms of F, f and m.

3) Determine the expression of the speed V of the skier in terms of F , f , m and the time t.

4) Deduce F.

B – Motion of the skier on the board BD

1) Why can we apply the principle of conservation of the mechanical of energy of system [(S), Earth] on the path BD?
2) Deduce that $V_D = 2$ m/s.

C – Motion of the skier between D and E

The skier leaves the board at point D, at an instant t_0, taken as a new origin of time.

1) Apply Newton's second law on the skier to show that, at an instant t, the vertical component P_y of the linear momentum of the skier is of the form: $P_y = 800\,t - 80$ (In SI unit).
2) Deduce the parametric equation y(t) of the motion of the skier in the frame of reference Dxy.
3) Determine the duration taken by the skier to pass from D to E.

<u>Second exercise</u>: (7 points)

Electromagnetic induction and self-induction

A – Electromagnetic induction

A coil, of horizontal axis, is made up of N = 500 circular turns each of surface area S = 10 cm^2. The normal $\vec{n}$ to the planes of the turns of the coil is directed as indicated in figure 1.

The coil rotates at a constant angular velocity ω about a vertical axis (Δ) in a horizontal, constant and uniform magnetic field $\vec{B}$. The terminals A and C of the coil are connected to the input Y and the ground M of an oscilloscope respectively. Let θ be the angle between $\vec{n}$ and $\vec{B}$ at an instant t.

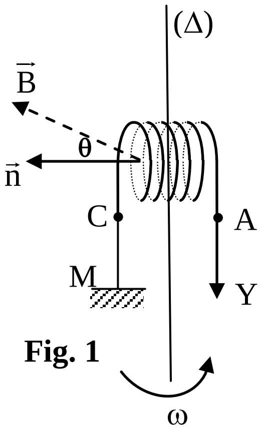
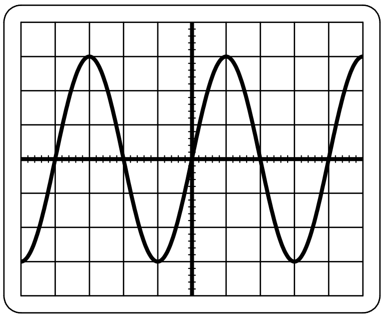


Fig. 1

1) Knowing that $\theta = 0$ at the instant $t_0 = 0$, show that $\theta = \omega t$.
2) Deduce that the expression of the magnetic flux crossing the coil is given by: $\phi = NBS\cos(\omega t)$.
3) Justify, qualitatively, the existence of an induced e.m.f "e" during the rotation of the coil.
4) **a)** Determine, in terms of N, S, B, ω and t, the expression of the induced e.m.f "e".
   b) The coil does not carry a current. Why?
   c) Deduce the expression of the voltage u_{AC} in terms of N, S, B, ω and t, supposing that the coil is oriented positively from A to C.

5) The waveform of figure 2 represents the variation of the voltage u_{AC} as a function of time. Using this waveform, determine:
   a) the angular velocity ω of the coil;
   b) the maximum value of the voltage u_{AC};
   c) the value B of the magnetic field $\vec{B}$.



$S_h = 10$ ms/div **Fig.2**
$S_V = 1$V/div

B – Self-induction

The coil is of negligible resistance and of inductance L. It is connected in series with a resistor of resistance R = 1 kΩ and a generator G (fig. 3).
The circuit of figure 3 thus carries a triangular current i. The positive orientation of the circuit is as that of the current.

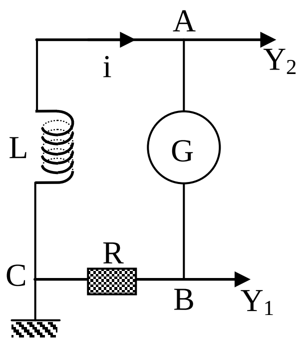
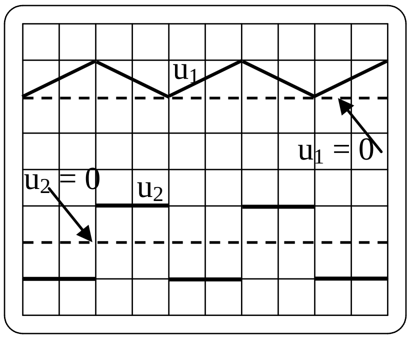


Fig. 3

With the aid of the oscilloscope, we visualize the variations of the voltages $u_1 = u_{BC}$ across the resistor and $u_2 = u_{AC}$ across the coil (fig. 4).

1) Show that $u_2 = -\frac{L}{R}\frac{du_1}{dt}$.
2) The shape of the waveform obtained on Y_2 is square. Justify this shape.
3) Determine the value of L.



S_h = 5 ms/div ; **Fig. 4**
S_{v1} = 1 V/div; S_{v2} = 10 mV/div

<u>Third exercise</u>: (6 points)

Sodium vapor lamp

A sodium vapor lamp emits mainly a yellow light called doublet of wavelengths 589.0 nm and 589.6 nm. Other wavelengths are also emitted, as those: λ_1 = 330.3 nm, λ_2 = 568.8 nm, λ_3 = 615.4 nm, λ_4 = 819.5 nm and λ_5 = 1138.2 nm.
Figure 1 below shows only the yellow doublet of the emission spectrum of the sodium atom.

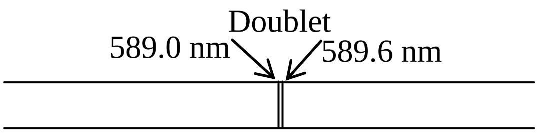


Fig. 1

Given : $h = 6.62\times10^{-34}$ J·s ; $c = 3\times10^{8}$ m/s; $1eV = 1.6\times10^{-19}$ J.

A – Spectrum analysis

1) To what range: visible, infrared or ultraviolet, does each of the radiations of the wavelengths λ_1 , λ_2 , λ_3 , λ_4 and λ_5 belong?
2) Is the sodium vapor lamp a monochromatic or a polychromatic source of light? Justify your answer.
3) Consider the yellow radiation of wavelength 589.0 nm. Show that the value of the energy of a photon corresponding to this radiation is approximately 2.11 eV.

B – Energetic analysis of the diagram

Figure 2 shows a simplified diagram of the energy levels of a sodium atom.

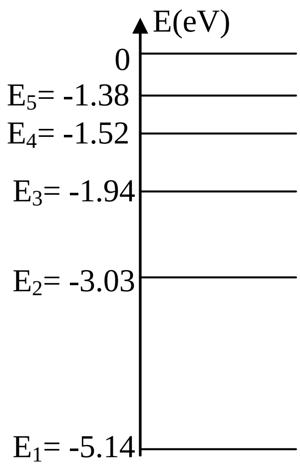


Fig. 2

1) **a)** One of these energy levels represents the ground state. Specify which one.
   b) What do we call each of the other shown levels?
2) **a)** Define the emission spectrum.
   b) Use the diagram of figure 2 to justify the discontinuity of the emission spectrum.
3) The emission of the yellow radiation of wavelength 589.0 nm is due to the transition of the sodium atom from an excited level E_n to the ground state. Determine E_n.
4) In fact, the energy level E_n is double. This double is constituted of two energy levels E_n and E'_n that are very close to each other. Compare, with justification, E_n and E'_n.
5) The sodium atom , being in an excited state E_x, receives a photon carrying an energy 1.51 eV and passes to another excited state E_y; E_x and E_y exist on the diagram of figure 2.
   a) Determine the two levels E_x and E_y.
   b) Is the spectral line associated with the transition $x \rightarrow y$ an emission or absorption line? Justify your answer.

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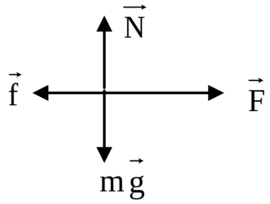
الاسم: الرقم:	مسابقة في مادة الفيزياء المدة ساعتان	مشروع معيار التصحيح

First exercise (7 points)

Part of the Q	Answer	Mark
A.1	I The forces acting on (S) are: the weight $m\vec{g}$, the normal reaction of the surface of water $\vec{N}$, $\vec{F}$ and $\vec{f}$. 	½
A.2	$\frac{d\vec{P}}{dt} = \Sigma\overrightarrow{F_{ext}} = \overrightarrow{mg} + \vec{N} + \vec{F} + \vec{f}$ project along the direction of motion $\Rightarrow$ $\frac{dP}{dt} = F - f \Rightarrow ma = F - f \Rightarrow a = \frac{F-f}{m}$	1
A.3	V = primitive of a = at $+V_o$ ($V_o = 0$) then $V = (\frac{F-f}{m})$ t.	¾
A.4	$V = V_B = 6$ m/s for t = 60 s $\Rightarrow 6 = (\frac{F-100}{80})60 \Rightarrow F = 108$ N	¾
B.1	Since friction is negligible between B and D	¼
B.2	$ME_B = ME_D \Rightarrow$ ½ $m(V_B)^2 + 0 =$ ½ $m(V_D)^2 + mgh$ $\Rightarrow$ ½(80)(36) = ½(80)$(V_D)^2 + 80\times10\times1.6 \Rightarrow V_D = 2$ m/s.	1
C.1	$\frac{d\vec{P}}{dt} = \Sigma\overrightarrow{F_{ext}} = mg\,\vec{j} \Rightarrow \frac{dP_y}{dt} = mg \Rightarrow P_y = mgt + P_{0y}$ $P_{0y} = mV_{0y} = m(-V_D \sin30^o) = -80\times2\times\frac{1}{2} = -80$ $\Rightarrow P_y = 800t - 80$	1
C.2	$V_y = \frac{P_y}{m} = 10t - 1 \Rightarrow y = 5t^2 - t + y_o = 5t^2 - t$ ($y_o = 0$).	¾
C.3	$1.6 = 5t^2 - t \Rightarrow 5t^2 - t + 1.6 = 0 \Rightarrow \Delta = 1 + 32 = 33$ $t = \frac{1 \pm \sqrt{33}}{10} \Rightarrow t = \frac{1+\sqrt{33}}{10} = 0.67$ s.	1

Second exercise (7 points)

Part of the Q	Answer	Mark
A.1	The angular velocity is constant, therefore: $\theta = \omega \cdot t + \theta_0$ with $\theta_0 = 0$	½
A.2	The magnetic flux through the coil is: $\phi = N\vec{B}\cdot S\vec{n} = NBS\cos(\theta) = NBS\cos(\omega t)$	¼
A.3	During the rotation of the coil, θ varies ⇒ magnetic flux varies , therefore e exists. Or ϕ is a function of time, then ϕ varies so e exists.	½
A.4.a	$e = -\frac{d\varphi}{dt} = -NBS[-\omega\sin(\omega t)] \Rightarrow e = NBS\,\omega\sin(\omega t)$.	½
A.4.b	Since the circuit is not closed (the resistance of the oscilloscope is too large or the circuit is open) .	¼
A.4.c	$u_{AC} = ri - e = -NBS\,\omega\sin(\omega t)$.	½
A.5.a	The period T = 40 ms ⇒ $\omega = \frac{2\pi}{T} = 157$ rd/s.	¾
A.5.b	$u_{AC}(max) = 3\text{ div} \times 1\text{V} = 3$ V.	¼
A.5.c	$u_{AC}(max) = NBS\,\omega$ $\Rightarrow B = \frac{u_{AC}(max)}{NS\omega} = \frac{3}{500\times10\times10^{-4}\times157} = 0.038T$.	¾
B.1	$u_2 = u_{AC} = e - ri = e = -L\frac{di}{dt}$ and $u_1 = R\,i \Rightarrow i = \frac{u_1}{R} \Rightarrow \frac{di}{dt} = \frac{1}{R}\frac{du_1}{dt}$ Thus $u_2 = -\frac{L}{R}\frac{du_1}{dt}$.	1
B.2	In the first half period, i is a linear function of time (i = at + b) ⇒ $u_1 = Ri = Rat + Rb$ $u_2 = -\frac{L}{R}\frac{du_1}{dt} = -\frac{L}{R}Ra = -La$ = constant. In the second half period, same explanation gives $u_1 = La$, Therefore the form of u_2 is a square.	¾
B.3	In the first half period : $\frac{du_1}{dt} = \frac{1\times1}{2\times5\times10^{-3}} = 100$ V/s and $u_2 = -10\times10^{-3}$ V $= -\frac{L}{1000}\times100 \Rightarrow L = 0.1$ H or 100 mH.	1

Third exercise (6 points)

Part of the Q	Answer	Mark
A.1	λ_1 : U.V ; λ_2 and λ_3: visible ; λ_4 and λ_5 : I.R.	¾
A.2	It is polychromatic since it is formed of many wavelengths (radiations).	½
A.3	$E = h\nu = h\frac{c}{\lambda} = 3.37\times10^{-19}$ J = 2.11 eV	½
B.1.a	The energy level – 5.14 eV corresponds to a ground state, since it is the lowest energy level.	½
B.1.b	E_2, E_3,E_4 and E_5 are excited state. The energy level 0, corresponds to the ionization state	½
B.2.a	The emission spectrum is the set of spectral lines emitted by an atom.	¼
B.2.b	To each electronic transition between two energy levels corresponds an emission line and since the energy levels diagram of the sodium atom are discontinious, then the spectral lines must be discontinuous.	½
B.3	$E_n - E_1 = 2.11$ eV ; $E_n = 2.11 + E_1 = 2.11 + (-5.14) = -3.03$ eV = E_2.	½
B.4	$\left.\begin{array}{l} E_n - (-5.14) = \frac{hc}{\lambda} \\ E'_n - (-5.14) = \frac{hc}{\lambda'} \end{array}\right\}$ $\boxed{\lambda' > \lambda \Rightarrow E'_n < E_n}$ **<u>Or</u>** : the variation of the energy ΔE is inversely proportional to the wavelength of the emitted radiation ; $\lambda' > \lambda$ and $\Delta E' < \Delta E \Rightarrow E'_n < E_n$	1
B.5.a	$E_y - E_x = 1.51$ eV corresponds to $E_4 - E_2 = 1.51$ eV. Thus $E_x \rightarrow E_2$ and $E_y \rightarrow E_4$	½
B.5.b	The associated spectral line is an absorption line because the atom passes from one level to a higher energy level, so it absorbs energy.	½