وزارة التّربية والتّعليم العالي المديريّة العامّة للتّربية دائرة الامتحانات الرسميّة	امتحانات الشهادة الثانويّة العامّة فرع العلوم العامّة	دورة العام ٢٠٢٤ العاديّة الإثنين ١ تموز ٢٠٢٤

مسابقة في مادّة الفيزياء المدّة: ساعتان ونصف	الاسم: الرّقم:

يتكوّن هذا الامتحان من ستة تمارين، موزعة على ست صفحات. يجب اختيار **أربعة تمارين فقط**.
إقرأ الأسئلة كلّها بشكل عام وشامل، ومن ثمّ حدّد اختياراتك.
ملاحظة: في حال الإجابة عن أكثر من أربعة تمارين، عليك شطب الإجابات المتعلقة بالتمارين التي لم تعد من ضمن اختيارك، لأن التصحيح يقتصر على إجابات التمارين، الاربع الاولى غير المشطوبة، بحسب ترتيبها على ورقة الاجابة. يمكن الاستعانة بالآلة الحاسبة غير القابلة للبرمجة.

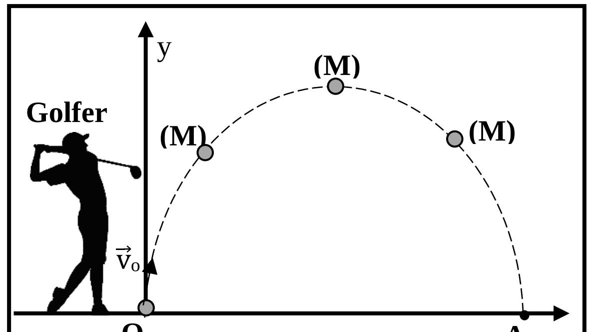
Exercise 1 (5 pts) Motion of a Golf Ball

The aim of this exercise is to study the motion of a golf ball (M) in two different shots. (M) is considered as a particle of mass m = 45 g.

1) First shot

At an instant $t_0 = 0$ s, a golfer hits (M) from point O, launching it with a velocity $\vec{v}_0$ of magnitude v_0.

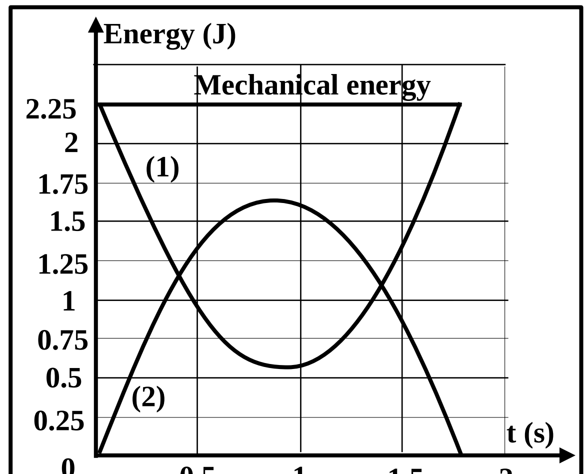
The ball (M) then moves in a vertical plane (xOy) containing $\vec{v}_0$, and then it reaches the ground at point A (Doc. 1).



Doc. 1

Take the horizontal plane passing through O and A as the reference level of gravitational potential energy.

The curves of document 2, represent the gravitational potential energy, the kinetic energy and the mechanical energy of the system [(M) - Earth] as functions of time t, during the motion of (M) between O and A.



Doc. 2

1.1) Using document 2:

1.1.1) Show that during the motion of (M) between O and A air resistance is neglected.

1.1.2) Show that curve (1) represents the kinetic energy and curve (2) represents the gravitational potential energy.

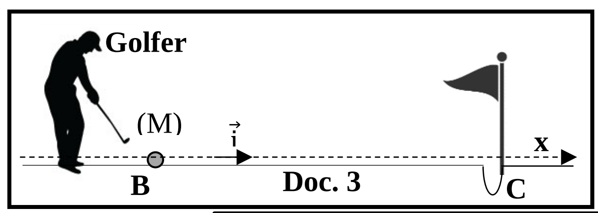
1.1.3) Calculate the value of v_0.

1.2) The ball hits the ground at A and then it stops at point B. Determine the variation of the internal energy ΔU of the system [(M) - Earth - Atmosphere] between O and B.

2) Second shot

At an instant $t_0 = 0$, taken as a new initial time, the golfer hits (M), from B. (M) is launched with a velocity $\vec{v}_B = v_B\,\vec{i}$.

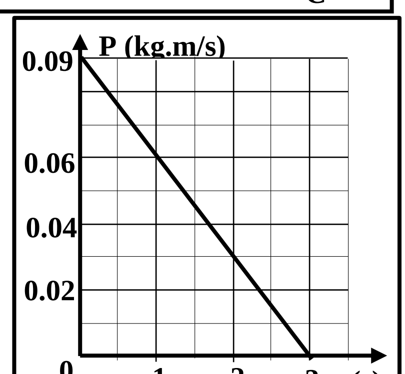
(M) moves along a horizontal straight line (BC) confounded with a horizontal x-axis of unit vector $\vec{i}$. The aim of this shot is to enter (M) in a hole at C, located 4.5 m from B (Doc. 3).



Doc. 3

During its motion, (M) is subjected to a force of friction $\vec{f}$ of constant magnitude f.

The curve in document 4 represents the magnitude of the linear momentum « P » of (M), as a function of time, during its motion between $t_0 = 0$ and $t_1 = 3$ s.



Doc. 4

2.1) Using document 4, calculate:

2.1.1) the value of v_B;

2.1.2) the variation $\Delta\vec{P}$ of the linear momentum of (M) between t_0 and t_1.

2.2) Show that f = 0.03 N, knowing that $\Delta\vec{P} = (\Sigma\vec{F}_{ext}).\Delta t$, where $\Sigma\vec{F}_{ext}$ is the sum of the external forces exerted on (M) during $\Delta t = t_1 - t_0$.

2.3) Calculate the variation of the mechanical energy of the system [(M) - Earth] between t_0 and t_1.

2.4) Deduce whether the ball reaches the hole at C.

Exercise 2 (5 pts) **Capacitive level sensors**

The aim of this exercise is to determine the capacitance of a capacitor in a capacitive level sensor.
Read carefully document 5 then answer the questions.

A capacitive level sensor uses a capacitor to measure the level of a product in a tank or reservoir (Doc. 6). It can be used to measure the level of liquids, granular solids, mud, etc.
The operation of the sensor is based on the variation of the capacitance of a capacitor. An increase in the product level will result in an increase in the sensor's capacitance. **www.automation-sense.com**

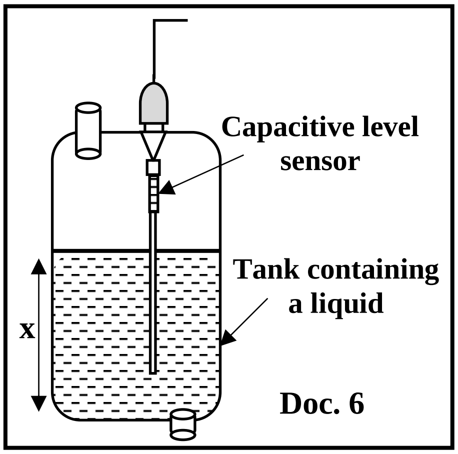
Doc. 5

1) Empty tank

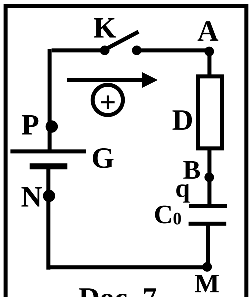
The sensor is placed in an empty tank, and the capacitance of the capacitor is then C_0. Document 7 represents a simplified circuit in a capacitive level sensor. The circuit includes in series:

- an ideal battery (G) of electromotive force E = 5 V;
- a resistor (D) of resistance R;
- a capacitor, initially uncharged, of capacitance C_0;
- a switch (K).

At $t_0 = 0$, (K) is closed and the charging process of the capacitor starts.
At an instant t, the plate B of the capacitor carries a charge q and the circuit carries a current i.



Doc. 6



Doc. 7

1.1) Show that the differential equation that describes the variation of q has the form:

$$\frac{dq}{dt} + \frac{1}{RC_0} q = \frac{E}{R}.$$

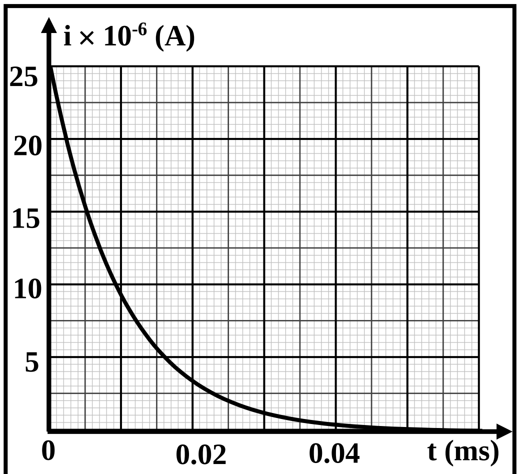
1.2) Show that $q = EC_0 - EC_0\, e^{\frac{-t}{RC_0}}$ is a solution of this differential equation.

1.3) Deduce the expression of i in terms of E, R, C_0 and t.

1.4) The curve of document 8, shows i as a function of time.
Using document 8, determine:

1.4.1) the value of R;

1.4.2) the value of C_0.



Doc. 8

2) Tank containing oil

The tank is filled with oil to a height x.
The table below gives for each height x of oil, the corresponding capacitance C of the sensor.

x (cm)	20	40	60	80
C (pF) ; (1 pF = 10^{-12} F)	80	110	140	170

2.1) Pick the sentence from document 5 that is in agreement with the obtained results.

2.2) Trace, on a graph paper, the curve that represents C as a function of x.

Take the scale:

- on the abscissa axis: 1 cm ↔ 20 cm ;
- on the ordinate axis: 1 cm ↔ 20 pF.

2.3) Referring to the obtained curve, show that: C = 50 + 1.5 x (C in pF and x in cm).

2.4) Deduce again the value of C_0.

2.5) If the maximum height that the oil tank can contain is 1m, deduce the maximum capacitance of the capacitive sensor in this case.

Exercise 3 (5 pts) Electromagnetic induction - braking of a drop tower

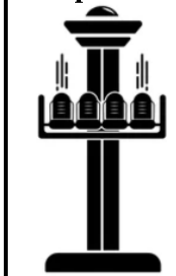
The aim of this exercise is to study the role of electromagnetic induction in the braking of the cabin of a drop tower that drops vertically at high speed (Doc. 9).

The circuit of the braking system in the cabin is simplified by an un-deformable vertical square-shaped loop (MNPQ), made of copper, of side « ℓ » and resistance R. The loop moves in a vertical plane, enters a rectangular region (DEFG) of a uniform magnetic field $\vec{B}$ of constant magnitude, perpendicular to the plane of the loop. The x-axis, of origin O the midpoint of [EF] is directed positively downward (Doc. 10).

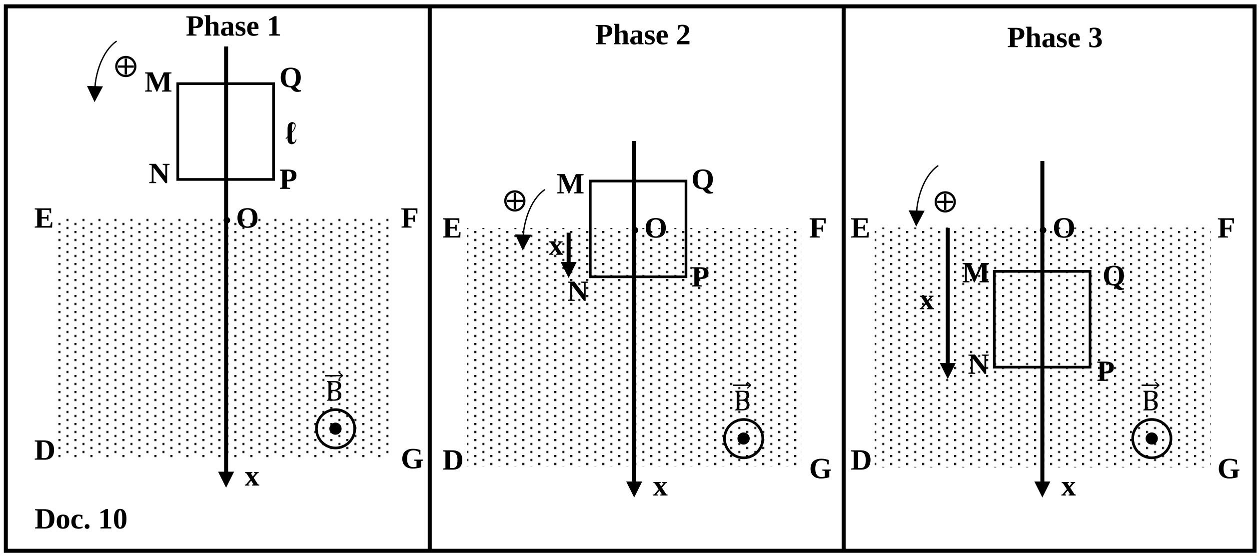
At an instant t, the abscissa of point N is x and the speed of the loop $v = x' = \frac{dx}{dt}$.

- Phase 1: The loop moves outside the region of the magnetic field ($x < 0$).
- Phase 2: The loop enters partially the region of the magnetic field ($0 < x < \ell$).
- Phase 3: The loop becomes completely in the region of the magnetic field ($x > \ell$).

Drop Tower



Doc. 9



Doc. 10

1) Match each of the expressions 1, 2 and 3 with the appropriate phase. Justify.

Expression 1: The magnetic flux through the loop is zero.

Expression 2: The magnetic flux through the loop is constant and non-zero.

Expression 3: The magnetic flux through the loop increases.

2) During phase 2:

2.1) Respecting the positive direction indicated in document 10, determine the expression of the magnetic flux Φ through the loop in terms of B, ℓ and x.

2.2) Determine the expression of the induced electromotive force e.m.f « e » in the loop in terms of v, B and ℓ.

2.3) The induced current in the loop is given by $i = \frac{e}{R}$. Determine the expression of i in terms of v, B, R and ℓ.

2.4) Deduce the direction of the induced current in the loop.

2.5) Laplace force (electromagnetic force) helps to slow down the cabin. Justify.

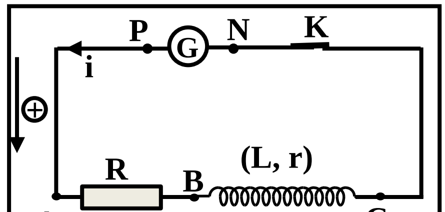
3) During phase 3, braking by electromagnetic induction does not exist. Justify.

Exercise 4 (5 pts) Self-induction

The aim of this exercise is to determine, by two different methods, the resistance r and the inductance L of a coil.

For this aim, we set-up the circuit of document 11 that includes:

- a coil of inductance L and resistance r;
- a resistor of resistance R = 10 Ω;
- a power supply (G);
- a switch (K).



Doc. 11

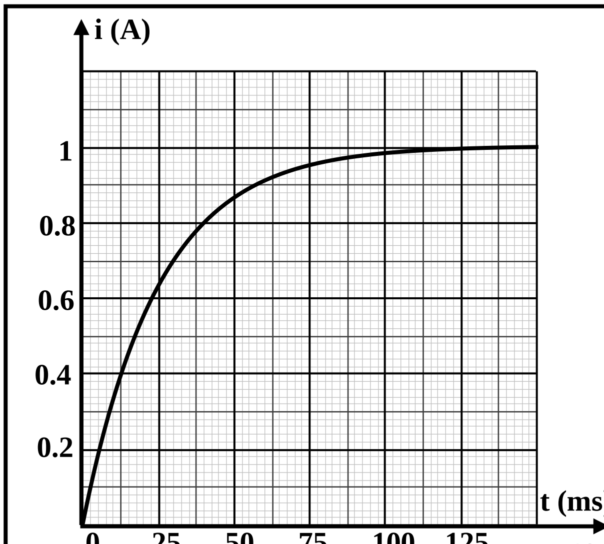
1) First method

The voltage across the power supply is $u_{PN} = E = 12$ V.

At an instant $t_0 = 0$, (K) is closed.

At an instant t, the circuit carries a current i.

Document 12 shows i as a function of time.



Doc. 12

1.1) Show that the differential equation that describes the variation of the current is: $L\frac{di}{dt} + (R + r)\,i = E$.

1.2) The solution of this differential equation is of the form: $i = I_m\,(1 - e^{\frac{-t}{\tau}})$, where I_m and τ are constants. Determine I_m and τ in terms of E, R, r and L.

1.3) Referring to document 12, indicate the value I_m.

1.4) Deduce the value of r.

1.5) Using document 12, determine the value of the time constant τ of the circuit.

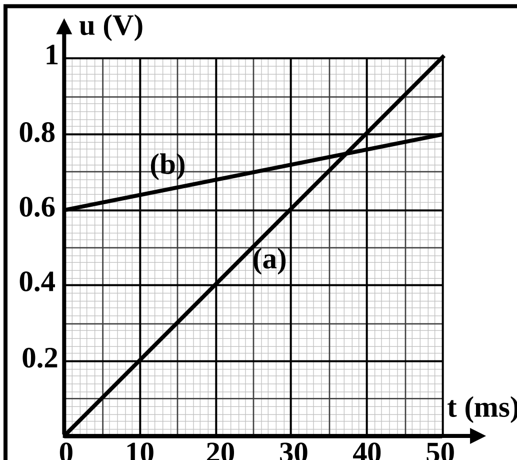
1.6) Deduce the value of L.

2) Second method

The power supply (G) delivers now a current i that varies with time according to this equation:

$$i = 2\,t \quad \text{(i in A and t in s)}.$$

Curves (a) and (b) of document 13, show the voltages $u_{AB} = u_R$ across the resistor and $u_{BC} = u_{coil}$ across the coil as functions of time.



Doc. 13

2.1) Write the expression of u_R as a function of t.

2.2) Write the expression of u_{coil} in terms of r, L and t.

2.3) Curve (a) represents u_R and curve (b) represents u_{coil}. Justify

2.4) Using document 13, determine the values of r and L.

Exercise 5 (5 pts) Wavelength of a radiation

The aim of this exercise is to determine the wavelength λ of a monochromatic light emitted by a source (S).

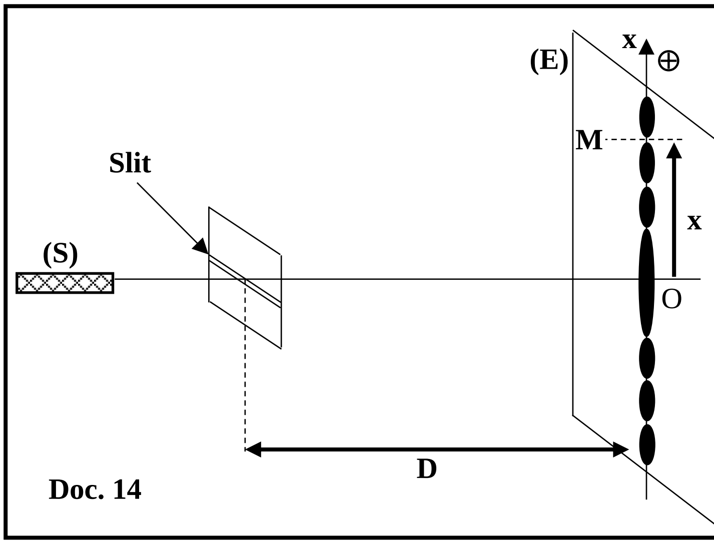
The monochromatic light, of wavelength λ, falls normally on a horizontal narrow slit of width « a ». The diffraction pattern is observed on a screen (E) placed perpendicularly to the incident light beam at a distance D from the slit (Doc. 14).

M, a point on (E), is the center of a dark fringe of order n (n is a non-zero integer) on the diffraction pattern.

The position of M is given by $x = \overline{OM}$ with respect to O, the center of the central bright fringe.

The diffraction angles in this exercise are small.

For small angles, take $\sin\theta \approx \tan\theta \approx \theta$ in radian.

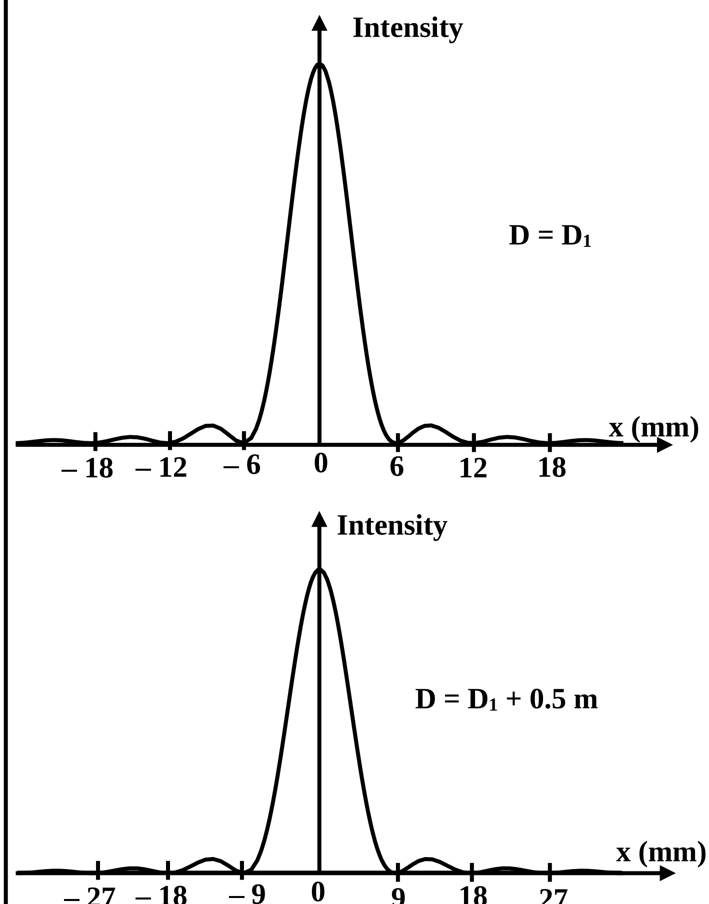


Doc. 14

1) Describe the diffraction pattern observed on (E).
2) Write, in terms of a, n and λ, the expression of the diffraction angle θ at M.
3) Show that the abscissa of M is $x = \overline{OM} = \dfrac{n\lambda D}{a}$.
4) The screen is placed at a distance $D = D_1$ from the slit, the center of the third dark fringe is at a position $x = x_3$ on the positive side of O.

   When the screen is moved 0.5 m away, the position of the center of the third dark fringe becomes $x = x'_3$ on the positive side O.

   Show that : $x'_3 - x_3 = 1.5\dfrac{\lambda}{a}$.
5) A sensor, sensitive to the intensity of light, is moved along the x - axis on the screen (E). The curves in document 15 show the light intensity as a function of x, for $D = D_1$ and for $D = D_1 + 0.5$ m. Using document 15, specify the values of x_3 and x'_3.
6) Deduce the values of λ and D_1 knowing that a = 0.1mm.



Doc. 15

Exercise 6 (5 pts) **Emission spectrum**

The emission spectrum of an excited gas is discontinuous.
This spectrum allows the identification of the chemical element emitting the radiation.
The aim of this exercise is to identify two gases, (A) and (B), using the emission spectrum of each.
Document 16 shows two simplified diagrams of the energy levels of gases (A) and (B).
Given: Planck's constant: $h = 6.627\times10^{-34}$ J·s; 1 eV = 1.602×10^{-19} J ; 1nm = 10^{-9} m; the speed of light in air: $c = 3\times10^{8}$ m/s.

1) During the transition of an atom from a level n of energy E_n to a level p of energy E_P (n > p), a photon of wavelength λ is emitted.
Show that $\lambda \cong \dfrac{1241}{E_n - E_P}$ with λ in nm and ($E_n - E_p$) in eV.

2) Identification of atom (A)

2.1) The ionization energy of atom (A) is $W_{ion} = 10.44$ eV. Determine the energy E_1 of this atom when it is in the ground state.

2.2) The arrows 1, 2, and 3 in the energy level diagram of atom (A) represent three possible transitions of this atom. Specify if the lines corresponding to these transitions are emission lines or absorption lines.

2.3) Calculate the wavelengths λ_1, λ_2 and λ_3 that correspond to these transitions.

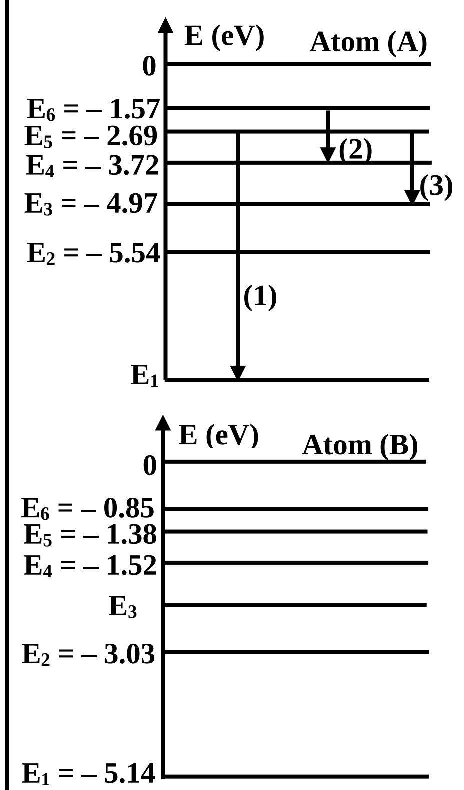
2.4) Using document 17, indicate the name of atom (A).

3) Identification of atom (B)

3.1) Atom (B), being in the ground state, receives a photon with frequency $\nu = 7.74\times10^{14}$ Hz and passes to the second excited level. Show that the energy E_3 of this atom is $E_3 = -1.94$ eV.

3.2) The de-excitation of atom (B) from the second excited level occurs through three different transitions. Indicate the three possible transitions.

3.3) The wavelengths corresponding to these transitions are: 387.81 nm, 588.15 nm and 1138.5 nm. Using document 17, indicate the name of atom (B).



Doc. 16

Chemical element	**Some wavelengths λ of the emission line spectrum (in nm)**			
Nitrogen	395.8	445	504.8	661
Hydrogen	364.6	434	486.1	656
Mercury	160.12	435.4	577.2	544.3
Oxygen	391	397	615.8	700
Sodium	387.81	568.8	588.15	1138.5

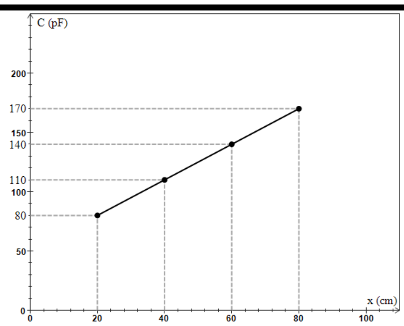
Doc. 17

مسابقة الفيزياء
أسس التصحيح - إنكليزي

Exercise 1 (5 pts) **Motion of a Golf Ball**

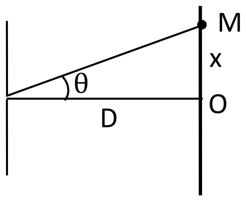
Part	Answer	Mark
1.1.1	Air resistance is neglected because **ME = constant = 2.25 J**	**0.25**
1.1.2	Curve (1): kinetic energy. First method: During ascending, the speed of (M) decreases, therefore the kinetic energy **(KE) of (M) decreases**. Second method: At $t_o = 0$ the speed of M is not zero, then **KE_o is not zero**. Curve (2): Gravitational potential energy. First method: During ascending the height of (M) increases, therefore during ascending the **gravitational potential energy of the system [(M)-Earth] increases**. Second method: At $t_o = 0$ the height of M is zero, then **GPE_o is zero.**	**0.25** **0.25**
1.1.3	At t = 0 s ; KE = 2.25 J $2.25 = \frac{1}{2} \times 0.045 \times v_0^2$; Then **V_0 = 10 m/s**	**0.25** **0.5**
1.2	The system [(M) – Earth – Atmosphere] is energetically isolated. Therefore, its total energy is conserved: E = ME + U = constant Then, $\Delta U = -\Delta(ME) = -(0 - 2.25) =$ **2.25 J**	**0.75**
2.1.1	$P_B = m\,v_B$; $0.09 = 0.045 \times v_B$; $v_B =$ **2 m/s**	**0.5**
2.1.2	$\Delta\vec{P} = \vec{p}_1 - \vec{p}_o = \mathbf{-0.09\,\vec{i}}$ $(kg.\frac{m}{s})$	**0.25**
2.2	$\sum \vec{F}_{ext} = m\vec{g} + \vec{N} + \vec{f}$; $m\vec{g} + \vec{N} = \vec{0}$, alors x-axis: $\sum \vec{F}_{ext} = \vec{f} = -f\,\vec{i}$ $\Delta\vec{P} \cong (\sum \vec{F}_{ext}).\Delta t$ then $-0.09\,\vec{i} = -f\,\vec{i} \times 3$ therfore f = 0.03 N **<u>or</u>** : $\Sigma\vec{F} = m\vec{g} + \vec{N} + \vec{f}$ mais $m\vec{g} + \vec{N} = \vec{0}$ then $\Sigma\vec{F} = -f\,\vec{i}$, $\Delta\vec{P} \cong (\sum \vec{F}_{ext}).\Delta t$ then along x-axis: $-0{,}09\,\vec{i} = -f\,\vec{i} \times 3$, therfore **f = 0.03 N**	**0.25** **0.25**
2.3	$\Delta ME = ME_2 - ME_1 = (KE_2 + GPE_2) - (KE_0 + GPE_0) = (KE_2) - (KE_0)$ $\Delta ME = \frac{1}{2}\,m\,(v_2^2 - v_A^2) = 0.5 \times 0.045\ (0 - 2^2) =$ **- 0.09 J**	**0.5**
2.4	$\Delta ME = W_{\vec{f}} = -f \times d$; $-0.09 = -0.03 \times d$, then **d = 3 m** < 4.5 m The ball **does not reach** the hole at C.	**1**

Exercise 2 (5 pts) Capacitive Level Sensors

Part	Answer	Mark
1.1	$u_{PN} = u_{PA} + u_{AB} + u_{BM} + u_{MN}$ $E = R\,i + u_C$; but $i = \frac{dq}{dt}$ and $u_C = \frac{q}{C_0}$ we obtain: $E = R\frac{dq}{dt} + \frac{q}{C_0}$ Divided by R $\frac{dq}{dt} + \frac{1}{RC_0}\mathbf{q} = \frac{E}{R}$	0.75
1.2	$q = EC_0 - EC_0\,e^{-\frac{1}{RC_0}t}$; $\frac{dq}{dt} = \frac{1}{RC_0}EC_0\,e^{-\frac{1}{RC_0}t}$; we replace q and $\frac{dq}{dt}$ in the differential equation: $\frac{1}{RC_0}EC_0\,e^{-\frac{1}{RC_0}t} + \frac{1}{RC_0}(EC_0 - EC_0\,e^{-\frac{1}{RC_0}t}) \overset{?}{=} \frac{E}{R}$ we obtain: $\frac{E}{R}e^{-\frac{1}{RC_0}t} + \frac{E}{R} - \frac{E}{R}e^{-\frac{1}{RC_0}t} \overset{?}{=} \frac{E}{R}$; therefore, $\frac{E}{R} = \frac{E}{R}$, Therefore, $q = EC_0 - EC_0\,e^{-\frac{1}{RC_0}t}$ is a solution	0.5
1.3	$i = \frac{dq}{dt} = \frac{1}{RC_0}EC_0\,e^{-\frac{1}{RC_0}t} = \frac{E}{R}\,e^{-\frac{1}{RC_0}t}$	0.25
1.4.1	At $t_0 = 0$ s ; $i = 25 \times 10^{-6} = \frac{E}{R}e^{0}$; then $2.5 \times 10^{-5} = \frac{5}{R}$ Therefore, **R = 200 000 Ω = 200 kΩ**	0.75
1.4.2	At $t = RC_0$; $i = 25 \times 10^{-6} \times 0.37 = 9.25 \times 10^{-6}$ A This value of i corresponds to t = 0.01 ms = RC_0 ; Therefore, $\mathbf{C_0 = 5 \times 10^{-11}}$ **F = 50 pF**	1
2.1	An increase in the product level will result in an increase in the sensor's capacitance.	0.25
2.2		0.5
2.3	The shape of the curve is a straight line whose extension does not pass through the origin, its equation is of the form: C = a x + b ; a = slope = (170 – 80)/(80 – 20) = 1.5 pF/cm For x = 20 cm , C = 80 pF ; thus 80 = 1.5 × 20 + b , then b = 50 pF We obtain C = 50 + 1.5 x (C in pF and x in cm)	0.5
2.4	C = 50 + 1.5 x ; when the tank is empty : x = 0 cm we obtain $C = C_0 = 50$ pF	0.25
2.5	For x_{max} = 1 m = 100 cm, we obtain $C_{max} = 50 + 1.5\,x_{max}$ = **200 pF**	0.25

Exercise 3 (5 pts) **Electromagnetic Induction Braking of a DropTower**		
Part	**Answer**	**grade**
1	**Expression 1**: The magnetic flux through the coil is zero → phase 1 Because the magnetic field lines do not pass through the plane of the coil. **Expression 2**: The magnetic flux through the coil is constant non zero → phase 3 Because there is a magnetic field crossing the loop with a constant value, no variation in the angle between $\vec{B}$ and $\vec{n}$, and no variation in the area covered by the magnetic field lines. **Expression 3**: The magnetic flux through the coil increases. → phase 2 because the surface S = x × ℓ covered by the magnetic flux increases, since x increases.	**0.5** **0.5** **0.5**
2.1	$\Phi = B.S.\cos(\vec{B}.\vec{n}) = B.x.\ell.\cos(0) = \mathbf{B\,\ell\,x}$	**0.5**
2.2	$e = -\frac{d\Phi}{dt} = -B\,\ell\,\frac{dx}{dt} = \mathbf{-B\,\ell\,v}$	**0.5**
2.3	$i = \frac{e}{R} = -\frac{\mathbf{B\,\ell\,v}}{\mathbf{R}}$	**0.5**
2.4	i < 0 therefore the direction of the induced current **is opposite to the chosen positive** direction (clockwise).	**0.5**
2.5	Since i is from P to N (clockwise) The magnetic field is out of the page. Therefore, the induced electromagnetic force is upwards, which **opposes** the motion of the loop and helps slow down the cabin of the drop tower. **<u>or</u>** According to Lenz's law Laplace force (electromagnetic force) **opposes** the motion of the moving loop.	**0.5** **0.5**
3	The magnetic flux through the coil is constant, then there is no induced electromagnetic force and no induced current, therefore Laplace force (electromagnetic force) **becomes zero**. Then, breaking by electromagnetic induction does not exist.	**0.5**

Exercise 4 (5 pts)	self-induction	
Part	**Answer**	**Mark**
1.1	$u_{PN} = u_{AB} + u_{BC}$; $u_G = u_R + u_{coil}$ $E = R\,i + r\,i + L\frac{di}{dt}$ Then $(R + r)\,i + L\frac{di}{dt} = E$	**0.5**
1.2	$i = I_m(1 - e^{\frac{-t}{\tau}}) = I_m - I_m e^{\frac{-t}{\tau}}$ then $\frac{di}{dt} = \frac{I_m}{\tau} e^{\frac{-t}{\tau}}$, we replace in the differential equation: $(R + r) I_m - (R + r) I_m e^{\frac{-t}{\tau}} + L\frac{I_m}{\tau} e^{\frac{-t}{\tau}} = E$ $I_m e^{\frac{-t}{\tau}} [\frac{L}{\tau} - (R + r)] + (R + r) I_m = E$; This is verified at any time t, then by identification $(R + r) I_m = E$ and $[\frac{L}{\tau} - (R + r)] = 0$; since $I_m e^{\frac{-t}{\tau}} \neq 0$ Therefore $\mathbf{I_m} = \frac{E}{R+r}$ and $\boldsymbol{\tau} = \frac{L}{R+r}$	**1.25**
1.3	$I_m = 1$ A	**0.25**
1.4	$I_m = \frac{E}{R+r}$; $1 = \frac{12}{10+r}$, therefore **r = 2 Ω**	**0.5**
1.5	At $t = \tau$: $i = 0.63\, I_m = 0.63$ A From the curve : i = 0.63 A for **t = τ = 25 ms**	**0.5**
1.6	$\tau = \frac{L}{R+r}$; $0.025 = \frac{L}{12}$ then **L = 0.3 H**	**0.5**
2.1	$u_R = R\,i$ then $u_R = 20\,t$	**0.25**
2.2	$u_{coil} = r\,i + L\frac{di}{dt}$ then $u_{coil} = 2\,r\,t + 2\,L$	**0.25**
2.3	(b) represents u_{coil}, because $u_{coil} = 2\,r\,t + 2\,L$ with r and L constant its shape must be a straight line that does not pass through the origin. The curve (a) is a straight line passing the origin which is in agreement with $u_R = 20$ t	**0.5**
2.4	$u_{coil} = 2\,r\,t + 2\,L$ At t = 0: 0.6 = 2 L then **L = 0.3 H** At t = 0.05 s: 0.8 = 0.1 r + 0.6 then **r = 2 Ω**	**0.25** **0.25**

Exercise 5 (5 pts)	wavelength of a radiation	
Part	**Answer**	**Mark**
1	We observe on the screen: ▪ Alternating bright and dark fringes on both sides of a central bright fringe. ▪ The central fringe is more intense, and has a width double that of the other bright fringes. ▪ The direction of the fringes is perpendicular to the direction of the slit.	**0.75**
2	$\boldsymbol{\theta = \frac{n\lambda}{a}}$	**0.5**
3	In the right triangle of vertices O, M and the center of the slit :  $\tan\theta \cong \theta = \frac{x}{D}$, then $x = \theta D = \frac{n\lambda D}{a}$	**0.75**
4	$x_3 = \frac{3\lambda D_1}{a}$ et $x'_3 = \frac{3\lambda D_2}{a} = \frac{3\lambda(D_1+0,5)}{a} = \frac{3\lambda D_1}{a} + 1,5\frac{\lambda}{a} = x_3 + 1,5\frac{\lambda}{a}$ Donc : $x'_3 - x_3 = 1.5\frac{\lambda}{a}$	**1**
5	At the center of a dark fringe, the intensity is zero. The third zero intensity from the center O of the central fringe is at $\mathbf{x_3 = 18\ mm}$. The third zero intensity from the center O of the central fringe is at $\mathbf{x'_3 = 27\ mm}$.	**0.5** **0.5**
6	$x_3 = 18$ mm and $x'_3 = 27$ mm. Then $(27 - 18)\times10^{-3} = 1.5\frac{\lambda}{a}$; therefore : $\frac{\lambda}{a} = 6\times10^{-3}$ $\lambda = 6\times10^{-3}\times a = 6\times10^{-7}$ m = **600 nm** $x_3 = \frac{3\lambda D_1}{a}$; $D_1 = \frac{a\,x_3}{3\lambda} = \frac{0.1\times10^{-3}\times18\times10^{-3}}{3\times600\times10^{-9}}$ = **1 m**	**0.5** **0.5**

Exercise 6 (5 pts)	Emission spectrum	
Part	**Answer**	**Mark**
1	$E_{photon} = E_n - E_P$; $\frac{h \times c}{\lambda} = E_n - E_P$; $\lambda = \frac{h \times c}{E_n - E_p} = \frac{6627 \times 10^{-34} \times 3 \times 10^{8} \times 10^{9}}{(E_n - E_p) \times 1.602 \times 10^{-19}} = \frac{1241{,}011}{(E_n - E_p)} \cong \frac{1241}{E_n - E_p}$	**0.5** **0.5**
2.1	$W_{ion} = E_\infty - E_1$, then $E_1 = E_\infty - W_{ion} = 0 - 10.44 =$ **– 10. 44 eV**	**0.5**
2.2	Emission lines Because the atom makes transitions from a **higher to a lower level**.	**0.25** **0.25**
2.3	$\lambda_1 = \frac{1241}{E_5 - E_1} = \frac{1241}{-2.69+10.44} = \mathbf{160.12\ nm}$; $\lambda_2 = \frac{1241}{E_6 - E_4} = \frac{1241}{-1.57+3.72} = \mathbf{577.2\ nm}$; $\lambda_3 = \frac{1241}{E_5 - E_3} = \frac{1241}{-2.69+4.97} = \mathbf{544.29\ nm}$	**0.75**
2.4	From document 17, atom « A » is **mercury**	**0.5**
3.1	$E_{photon} = E_3 - E_1$; $h \times \nu = E_3 - E_1$ then : $E_3 = E_1 + h \times \nu$ $E_3 = -5.14 + (\frac{6.627 \times 10^{-34} \times 7.74 \times 10^{14}}{1.602 \times 10^{-19}}) =$ **– 1.94 eV**	**0.5**
3.2	Transition 1 : $E_3 \rightarrow E_1$ Transition 2 : $E_3 \rightarrow E_2$ Transition 3: $E_2 \rightarrow E_1$	**0.25** **0.25** **0.25**
3.3	From document 17; atom « B » is **sodium**	**0.5**