الدورة الإستثنائية للعام **2010**	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</u>.
<u>The use of non-programmable calculators is recommended.</u>

<u>First Exercise</u>: (7 points) ***Study of an RLC series circuit***

The circuit of (fig. 1) is formed of a coil(L, r) **,** a resistor of resistance $R = 50\ \Omega$ and a capacitor of capacitance $C = 64\ \mu F$ all connected in series across a generator G that maintains , across its terminals A and D, an alternating sinusoidal voltage of adjustable frequency f and of constant effective value U. The circuit thus carries an alternating sinusoidal current i whose expression as a function of time is given by:
$i = I_m \sin(2\pi f t)$ (i in A, t in s).
An oscilloscope, conveniently connected, allows us to display the voltage u_{BM} across the coil on channel Y_1, and the voltage u_{MD} across the resistor on channel Y_2. We obtain the waveforms (a) and (b) represented in figure 2.
The vertical sensitivity on both channels is 2V/div.
The horizontal sensitivity is 5 ms/div.
Take: $0.32\pi = 1$.

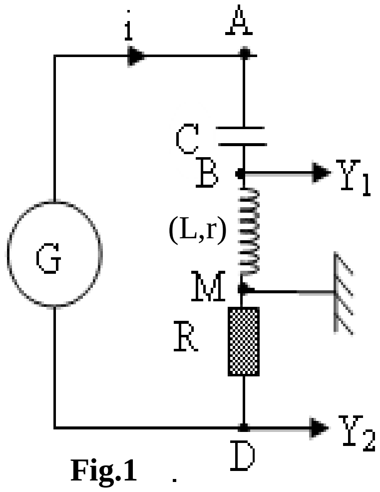


Fig.1

1) The button "INV" of channel Y_2 is pressed. Why?
2) Which one of the two waveforms represents the voltage u_{BM}? Why?
3) Referring to figure 2,
   a) calculate f ;
   b) ***i)*** calculate the phase difference between the voltages u_{BM} and u_{MD};
   ii) deduce that the coil has no resistance;
   c) calculate the maximum voltage $U_{BM(max)}$ across the coil;
   d) calculate the maximum voltage $U_{MD(max)}$ across the resistor.
4) Show that the expression of the voltage u_{MD} is of the form:
   $u_{MD} = 7 \sin(100\pi t)$ (u_{MD} in V, t in s).
5) Determine , as a function of time, the expression of :
   a) the current i ;
   b) the voltage u_{BM} ;
   c) the voltage u_{AB} across the capacitor.
6) ***a)*** Applying the law of addition of voltages , determine the expression of the voltage u_{AD} across the generator as a function of time.
   b) ***i)*** Deduce that the average electric power P consumed in the circuit is maximum.
   ii) Calculate P.

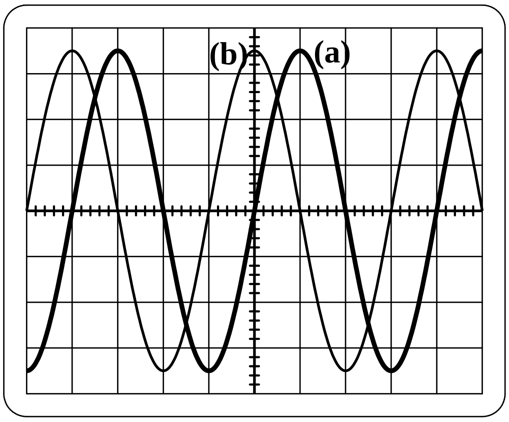


Fig.2

Second Exercise: ***(6 points)*** **Photoelectric effect**

A metallic plate, covered with a layer of cesium, is illuminated with a monochromatic luminous beam of wavelength $\lambda = 0.45 \times 10^{-6}$ m in vacuum.
The work function (extraction energy) of cesium is $W_0 = 1.88$ eV.
A convenient apparatus (D) is used to detect the electrons emitted by the illuminated plate.

Given: Planck's constant $h = 6.6 \times 10^{-34}$ J.s; speed of light in vacuum $c = 3 \times 10^{8}$ m/s;
1 eV = 1.6×10^{-19} J; elementary charge $e = 1.6 \times 10^{-19}$ C.

1) What aspect of light does the phenomenon of photoelectric effect show evidence of ?

2) Define the term "work function" of a metal.

3) The luminous beam illuminating the metallic plate is formed of photons.

- ***a)*** ***i)*** Write down the expression of the energy E of a photon in terms of h, c and λ.
  - ***ii)*** Calculate, in eV, the energy of an incident photon.
- ***b)*** (D) detects electrons emitted by the plate.
  Why do we have an emission of electrons by the plate?
- ***c)*** Calculate, in eV, the maximum kinetic energy of an emitted electron.

4) The luminous power P received by the plate is 10^{-3} W, and the emitted electrons form a current $I = 5\ \mu A$.

- ***a)*** Calculate the number n of photons received by the plate in one second.
- ***b)*** Knowing that the current I is related to the number N of the electrons emitted per second and to the elementary charge e by the relation: $I = N \times e$. Calculate N.
- ***c)*** ***i)*** Calculate the quantum efficiency $r = \frac{N}{n}$.
  - ***ii)*** Deduce that the number of effective photons in one second is relatively small.
- ***d)*** We increase the luminous power P received by the plate without changing the wavelength λ.
  Would the current increase or decrease? Why?

Third Exercise: *(7 points)* **Resistive force on a car**

A car of mass M = 1500 kg moves on a straight horizontal road; its center of gravity G is moving on the axis $(O, \vec{i})$.

The car is acted upon by the forces:

- its weight;
- the normal reaction of the road;
- a constant motive force $\vec{F}_m = F_m \, \vec{i}$ where $F_m = 3500$ N;
- a resistive force $\vec{F}_f = -F_f \, \vec{i}$.

In order to determine F_f, we measure the speed V of the car at different instants, separated by equal time intervals each being $\tau = 1$ s.

A – Value of $\vec{F}_f$ between the instants $t_0 = 0$ and $t_5 = 5$ s

The results of the obtained recordings are tabulated as follows:

Instant	$t_0 = 0$	$t_1 = \tau$	$t_2 = 2\,\tau$	$t_3 = 3\,\tau$	$t_4 = 4\,\tau$	$t_5 = 5\tau$
Position	O	G_1	G_2	G_3	G_4	G_5
V(m/s)	0	2	4	6	8	10

1) Using the scale below, draw the curve representing the variation of the speed V as a function of time.
- 1 cm on the axis of abscissas represents 1 s;
- 1 cm on the axis of ordinates represents 1 m/s.

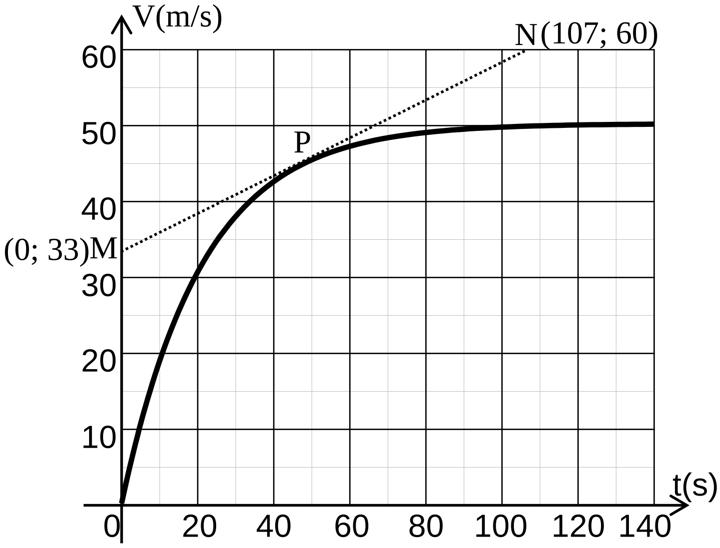
2) Show that the relation between the velocity $\vec{V} = V\vec{i}$ at a time t has the form $\vec{V} = b\,t\,\vec{i}$ where b is a constant.

3) ***a)*** the constant b is a characteristic physical quantity of motion. Give its name .
b) Calculate its value.

4) Applying Newton's second law,
a) show that F_f is constant between $t_0 = 0$ and $t_5 = 5$ s;
b) calculate the value F_f of $\vec{F}_f$.

B – Variation of F_f between the instants $t_5 = 5$ s and t = 140 s

In reality, the measurement of the speed between the instants $t_0 = 0$ and t = 140 s allows us to plot the graph of the adjacent figure.



1) Show that the part of this graph between the instants $t_0 = 0$ and $t_5 = 5$ s is in agreement with the graph of part A.

2) We draw the tangent MN to the curve at the point P at the instant t_P where $V_P = 45$ m/s.
a) Determine the value of the acceleration at the instant t_P.
b) Deduce the value of F_f at the instant t_P.

3) Starting from the instant 100s, V attains a limiting value of $V_\ell = 50$ m/s. Calculate then the value of F_f.

4) Indicate the time interval during which F_f increases.

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

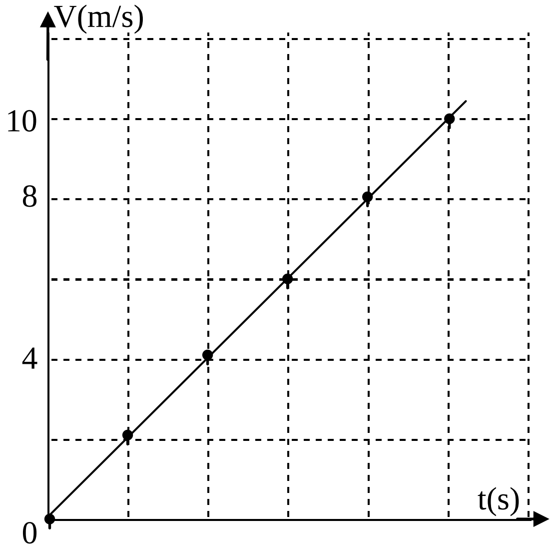
First Exercise (7 points)

Part of the Ex.	Answer	Mark
1	To display u_{MD} and not u_{DM}	0.25
2	The voltage of a coil leads the current i, thus (b) represents u_{BM}.	0.5
3.a	The period T corresponds to 4 div, thus T = 4 div×5 ms/div = 20 ms. $f = \frac{1}{T} = \frac{1}{20\times10^{-3}} = 50$ Hz	0.75
3.b.i	4 divisions correspond to a difference in phase 2π rad. 1 division corresponds to φ_1 rd, thus $\lvert\varphi_1\rvert = \frac{2\pi\times1}{4} = \frac{\pi}{2}$ rad.	0.75
3.bii	Phase difference between u_{BM} and i being $\frac{\pi}{2}$ rad, thus the coil has a negligible resistance	0.5
3.c	$u_{BM(max)}$ = 3.5 div×2 V/div = 7 V.	0.25
3.d	$u_{MD(max)}$ = 3.5 div×2 V/div = 7 V	0.25
4	u_{MD} is in phase with i $\Rightarrow u_{MD} = u_{MD(max)}\sin 2\pi ft = 7\sin(100\pi t)$	0.5
5.a	$u_{MD(max)} = RI_m \Rightarrow I_m = \frac{7}{50} = 0.14$ A $\Rightarrow i = 0.14\sin(100\pi t)$	0.5
5.b	$u_{BM} = u_{BM(max)}\sin(100\pi t + \frac{\pi}{2}) = 7\sin(100\pi t + \frac{\pi}{2}) = 7\cos(100\pi t)$	0.5
5.c	$i = C \Rightarrow \frac{du_{AB}}{dt}$ $U_{AB} = \frac{1}{C}$ primitive of $I = -\frac{0.14}{100\pi C}\cos(100\pi t)$. $i = -7\cos(100\pi t)$.	0.75
6.a	$u_{AD} = u_{AB} + u_{BM} + u_{MD}$ $u_{AD} = -7\cos(100\pi t) + 7\cos(100\pi t) + 7\sin(100\pi t)$. $u_{AD} = 7\sin(100\pi t)$	0.5
6.b.i	The phase difference between $u_{AD} = u_G$ and i is null, the circuit is the seat of current resonance where I_m is in this case has a maximum value. $\cos\varphi = 1$ is max. Thus P is max.	0.5
6.b.ii	$P = UI = \frac{0.14}{\sqrt{2}}\times\frac{7}{\sqrt{2}} = 0.49$ W.	0.5

Second Exercise: (6 points)

Part of the EX.	Answer	Mark
1	Corpuscular aspect of light	0.25
2	The extraction energy of a substance is the minimum energy needed to extract an electron from the substance	0.5
3.a.i	$E = \frac{hc}{\lambda}$	0.25
3.a.ii	E = $\frac{6.6\times10^{-34}\times3\times10^{8}}{0.45\times10^{-6}} = 44\times10^{-20}$ J = 2.75 eV.	0.75
3.b	Since E = 2.75 eV is > W_0 = 1.88 eV	0.5
3.c	Einstein's relation about photoelectric effect is: E = W_0 + KE $\Rightarrow$ KE = 2.75 – 1.88 = 0.87 eV	0.75
4.a	P = nE $\Rightarrow$ n = $\frac{1\times10^{-3}}{44\times10^{-20}} = 227\times10^{13}$ photons/s.	0.75
4.b	N = $\frac{5\times10^{-6}}{1.6\times10^{-19}} = 3.125\times10^{13}$ electrons/s	0.5
4.c.i	r = 0.014 = 1.4 %.	0.5
4.c.ii	r is small $\Rightarrow$ the number of effective photons per second is small	0.25
4.d	P = nE = $n\frac{hc}{\lambda}$;if we increase P keeping λ constant, $\Rightarrow$ n increases $\Rightarrow$N = number of emitted electrons increase But I = N $\times$ e $\Rightarrow$ I increases.	1

Third Exercise: (7 points)

Part of the Ex.	Answer	Mark
A.1		1
A.2	The graph is a straight line passing through the origin, in agreement with the function $\vec{V} = bt\vec{i}$ where b is a constant	0.5
A.3.a	b the acceleration of the motion;.	0.5
A.3.b	$b = \frac{\Delta V}{\Delta t} = \frac{10-0}{5} = 2 m/s^2$.	1
A.4.a	$\sum \vec{F}_{ext} = \frac{d\vec{P}}{dt} \Rightarrow \frac{d\vec{P}}{dt} = M\vec{g} + \vec{R} + \vec{F}_m + \vec{F}_f$. Projection along the horizontal: $M\frac{dV}{dt} = F_m - F_f \Rightarrow Mb = F_m - F_f$; F_m = const. M = const. and b = const. $\Rightarrow F_f$ = constant	1
A.4.b	$\Rightarrow F_f = F_m - mb$ $F_f = 3500 - 1500\times2 = 500$ N	0.5
B.1	For V < 10 m/s , the part of the curve is a straight line	0.5
B.2.a	$a = \frac{dV}{dt}$ is the slope of the tangent. $a = \frac{60-33}{107-0} = 0.25$ m/s^2	0.75
B.2.b	$F_f = 3500 - 1500\times 0.25 = 3125$ N.	0.5
B.3	$a = 0 \Rightarrow F_f = F_m = 3500$ N	0.5
B.4	5 s < t < 100 s	0.25