المادة: الفيزياء	الهيئة الأكاديميّة المشتركة
الشهادة: الثانوية العامّة	قسم : العلوم
الفرع: العلوم العامة	
نموذج رقم 1	
المدّة : ثلاث ساعات	

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

This Test Includes 4 Exercises. The Use of A Non-programmable Calculator Is Allowed.

Exercise 1 (6½ points)   Sodium vapor lamp

Sodium vapor lamps are used for illuminating road tunnels. These lamps contain sodium vapor at very low pressure. This vapor is excited by an electron beam which passes inside the tube. Sodium atoms absorb the energy of electrons. This energy is restored when the atom perform downward transition to the ground state in the form of light radiation.
Sodium vapor lamps mainly emit yellow light.
Given: $h=6.63\times10^{-34}$ J.s; $c=3.00\times10^{8}$ ms^{-1}; 1 eV= 1.60×10^{-19} J.

1) The analysis of the emission spectrum of a sodium-vapor lamp reveals the presence of spectral lines of well-defined wavelengths λ.

(Doc 1)

330.3 nm
568.8 nm   615.4 nm   819.5 nm   1138.2 nm
doublet 589.0 / 589.6
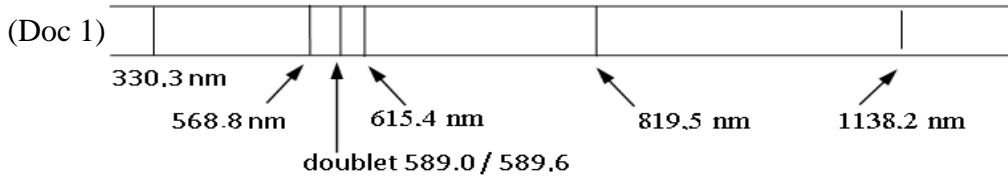
1-1) Identify the wavelengths belonging to the visible range, to the ultraviolet range, and to the infrared range.
1-2) Specify if the emission spectrum is a polychromatic or monochromatic light.
1-3) The corresponding emission spectrum is discontinuous. Explain
1-4) Calculate the energy in (eV) of the spectral line of wavelength $\lambda = 589.0$ nm.

2) The diagram of the energy levels of the sodium atom is given in the adjacent figure (Doc 2).
2-1) Calculate, in joule, the energy (E_0) of the atom when it is in the ground state.
2-2) Determine the minimum energy needed to excite the sodium atom from its ground state.
2-3) The sodium atom being in the third excited state:
**2-3-1)** Determine the minimum energy needed to ionize it.
2-3-2) Determine the wavelengths of the visible radiations emitted due to the de- excitation to the energy level $E_1= -3.03$ eV.
2-4) The sodium atom, now considered in the first excited state E_1, receives a light radiation of energy $E = 1.09$ eV. Can this light radiation interact with the sodium atom? Justify.
2-5) The sodium atom, being in the ground state, absorbs:
2-5-1) a photon which is associated to a radiation of wavelength of $\lambda = 289.33$ nm. Determine the state of the atom.
2-5-2) a photon of energy 6 eV. An electron is thus liberated by the atom. Calculate, in eV, the kinetic energy of that electron.

(Doc 2)

E(eV)

0

$E_5 = -0,85$

$E_4 = -1.38$

$E_3 = -1.52$

$E_2 = -1.94$

$E_1 = -3.03$

$E_0 = -5.14$
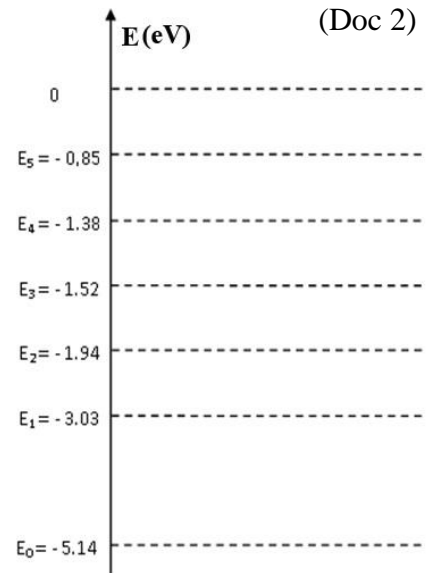
**Exercise 2 (7 Points)**   **Compound Pendulum**

1) In order to determine the proper period of a given compound pendulum, the following two procedures are done separately as shown in parts **1-1)** and **1-2)**.

1-1) Determination of the expression of T_0 in terms of x

The given compound pendulum is formed of a rod AB of length AB = L = 1 m and of mass M = 1.2 kg and a particle "m" of mass m = 500 g which can slide between A and O. "m" is fixed at point C such that AC= x. The pendulum can rotate in the vertical plane around a horizontal axis (Δ) passing through A. Let a = AG be the distance between A and the center of gravity G of the pendulum. (Doc 1)

The pendulum is shifted by an angle $\theta_o=8°$ from its equilibrium position, in the positive direction, and then released from rest at the instant $t_0 = 0$ s. Let θ and θ' be respectively the angular abscissa and angular velocity of the pendulum at an instant t. Take the horizontal plane containing A as the gravitational potential energy reference.

Use: $g=10m/s^2$; for $\theta < 10°$ $\sin\theta \approx \theta_{rad}$ and $\cos\theta \approx 1-\dfrac{\theta_{rad}^2}{2}$. Neglect all resistive forces.
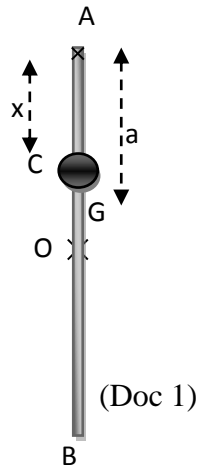
1-1-1) Show that the position of the center of gravity G of the system is given by the relation:
$$AG = a = \frac{2mx+ML}{2(m+M)}$$

1-1-2) Show that the moment of inertia I of the pendulum is written as: I= $(3mx^2 + ML^2)$ /3, knowing that the moment of inertia of the rod with respect to the axis Δ is: I (rod) =$ML^2/3$.

1-1-3) Determine the expression of the mechanical energy of the system (pendulum, Earth) in terms of m, M, g, a, I, θ and θ'.

1-1-4) Derive the differential equation in θ that governs the motion of the pendulum.

1-1-5) The solution of the differential equation is $\theta=\theta_m\cos(\omega_0 t + \varphi)$ where θ is in rad and t in sec. Determine θ_m and φ.

1-1-6) Deduce the expression of the proper period T_o in terms of x.

1-2) Determination of x

Now the system (rod AB & particle) is placed horizontally; it can rotate freely around the vertical axis (Δ) that passes through the midpoint O. The particle is fixed at the end C of a string OC (Doc 2). The system rotates with a constant angular speed of 2 rd/sec when the particle of mass m is at point C (AC = x). At a certain instant, the string is cut and the particle of mass m slides and sticks at the extremity A of the rod; the angular speed of the system becomes 1.5 rd/sec.
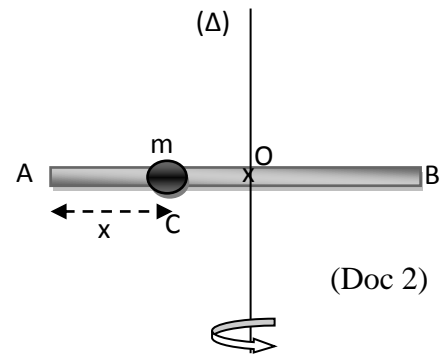
1-2-1) If I_1 is the moment of inertia of the system (rod AB & mass m) when m is at the point C and I_2 the moment of inertia of this system when m is at the extremity A, verify that:
$I_1 = 0.1 + 0.5(0.5-x)^2$ and $I_2 = 0.225$ kgm^2.
Knowing that the moment of inertia of the rod around the axis (Δ) passing through its center is $I_{(rod)/\Delta} = ML^2/12$

1-2-2) Apply the principle of conservation of angular momentum to determine x.

1-2-3) Using the results of parts A and B, deduce the value of the proper period T_o.

Exercise 3 (6½ points)   Aspect of Light

1) In a Young's set up *in air*, the two slits S_1 and S_2 that are
straight, parallel and separated by a distance **a = 1 mm** are
illuminated by the same source S that is equidistant from S_1 and
S_2, S emitting a monochromatic light of wavelength $\lambda = 625$ nm.
The screen of observation (P), parallel to the plane of S_1S_2, is
found at a distance $D = 1$ m from the point I, the mid-point of
S_1S_2. We (P), we consider a point M in the zone of interference
whose position is defined by its abscissa x relative to the point
O, the orthogonal projection of I on P. (Doc 1)

(Doc 1)
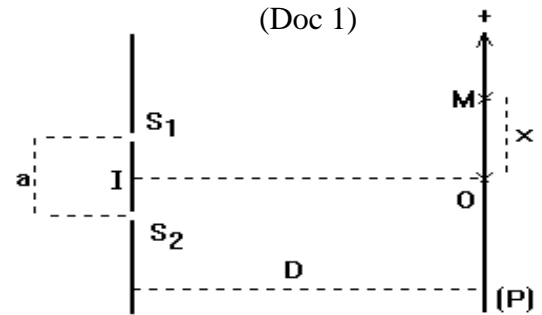
1-1) Specify the nature of the fringe whose center is at O.
1-2) Describe the fringes observed on the screen (P).
1-3) Interpret the existence of fringes.
1-4) Give, in terms of **D**, **a** and **x**, the optical path difference at point **M.**
1-5) Derive the expression of the abscissa of the centers of the dark fringes in terms of **D, a, x** and λ
1-6) Deduce the inter-fringe distance in terms of λ, **D** and **a**
1-7) Determine the type and order of the fringe at a point M on the screen whose distance from the
central fringe is 3.75 mm.
1-8) A parallel plate, of thickness e and index of refraction n = 1.5, is placed in front of S_1. The optical
path difference at M becomes: $S_2M - S_1M = \delta = ax/D - e(n-1)$.
The central fringe occupies now a position that was occupied previously by the 2nd dark fringe.
Determine e.

2) Now we cover the slit S_1 and the source S emitting the monochromatic
radiation, is placed facing the slit S_2 whose width is **0.1mm** (Doc 2).
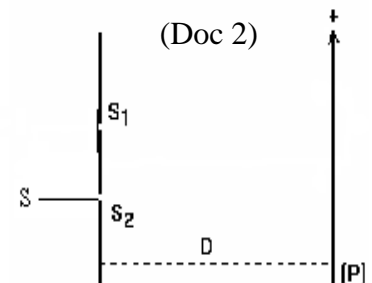
(Doc 2)

2-1) Name the phenomenon that the light undergoes through the slit.
2-2)
2-2-1) Give the expression of the width L of the central fringe observed
on the screen.
**2-2-2)** Calculate the width of the central fringe L observed on the screen
2-3) The preceding two optical phenomena show evidence of a particular
aspect of light. Identify this aspect.

Exercise 4 (7½ points)   Determination of the characteristics of electric components

The aim of this exercise is to determine the characteristics R, L and C of
a resistor of adjustable resistance R, a coil of inductance L and of
negligible resistance and a capacitor of capacitance C respectively.
For this, we perform the following two experiments:

(Doc 1)
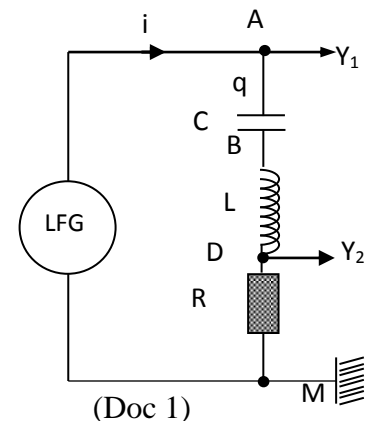
1) 1st experiment:

Consider a series circuit that consists of an LFG which delivers across its terminals an alternating sinusoidal voltage of effective value U and of adjustable frequency f, a pure resistor of resistance R, a coil of inductance L and of negligible resistance, a capacitor of capacitance C and an ammeter; A voltmeter, connected across the terminals of the LFG, reads a constant voltage U = 21 V.
We give f different values and we register, for each value of f, the effective current in the circuit. We obtain the graph plotted in (Doc 2) which gives I as a function of f. Take $\pi^2 = 10$.

1-1) The circuit is the seat of a certain phenomenon. Name the physical phenomenon that takes place for f = 200 Hz. Justify
1-2) Indicate the proper frequency f_0 of this circuit.
1-3) Calculate the value of R, knowing that the value I_0 of I corresponds to f = f_0.
1-4) Show that $LC = 0.625 \times 10^{-6}$ s^2.

2) 2nd experiment:

We give R the value R = 150 Ω
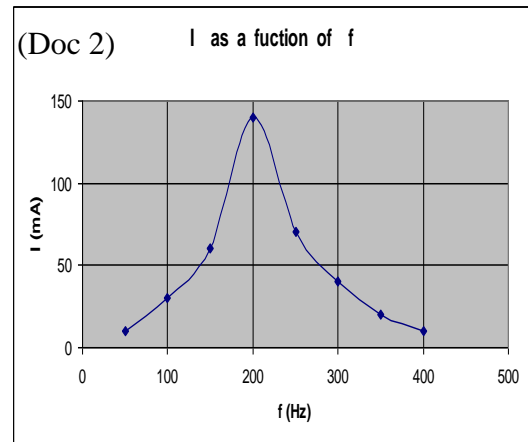The expression of the voltage across the terminals of the LFG is:
$u_{AM} = U_m \sin(2\pi f t)$.
The circuit thus carries an alternating sinusoidal current i.
The two channels of the oscilloscope are connected as shown to display the voltage u_{AM} across the LFG and the voltage u_{DM} across the resistor. (Doc 3) shows the waveform (1) corresponding to the voltage u_{AM} and the waveform (2) that corresponds to the voltage u_{DM}. The frequency of u_{AM} is adjusted to f = 50 Hz.
The vertical sensitivity on both channels is 5 V/division.
Take $\pi^2 = 10$.

(Doc 2) I as a fuction of f

2-1) Referring to the waveforms:
2-1-1) Calculate the maximum value U_m of u_{AM}.
2-1-2) Determine, as a function of time t, the expression of the voltage u_{DM}.
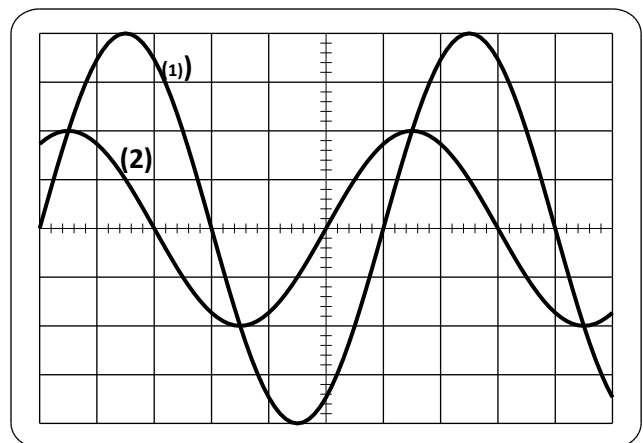**2-1-3)** Deduce the expression of i.
2-2)
2-2-1) Determine the expression of the voltage u_{AB} across the terminals of the capacitor.
2-2-2) Determine the expression of the voltage u_{BD} across the terminals of the coil.
2-2-3) Using the relation $u_{AM} = u_{AB} + u_{BD} + u_{DM}$ and giving t the value zero, show that the second relation between L and C is:

$$3.3\pi^2 LC + 10\pi \frac{\sqrt{3}}{2} C = \frac{0.066}{200} = 3.3 \times 10^{-4}$$

(Doc 3)

2-3) Conclusion:
Determine the values of L and C from the above two relations obtained between L and C.

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المدّة : ثلاث ساعات		

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

Exercise 1 (6½ points)   Sodium vapor lamp

Question	Answer	Mark
1-1	Visible range: 568.8 nm, 589.0 nm, 589.6 nm and 615.4 nm.	¼
	Ultraviolet range: 330.3 nm.	¼
	Infrared range: 819.5nm and 1138.2 nm	¼
1-2	Polychromatic since the emitted spectrum is formed of many radiations of different frequencies	¼
1-3	The energy of the atom cannot take any value; it takes only some discrete and particular values. The energy of the atom is quantized.	½
1-4	$E = hc/\lambda = 3.372 \times 10^{-19}$ J $= 2.11$ eV	½
2-1	$E = -5.14$ eV $= -8.22 \times 10^{-19}$ J	¼
2-2	It corresponds to an upward transition from the energy level E_0 to the energy level E_1.	
	$E_{min \ to \ excite \ the \ atom} = -3.03 + 5.14 = 2.11$ eV	½
2-3-1	It is an upward transition from the energy level E_3 to the ionized state $E_\infty = 0$. $E_{ioniz} = 1.52$ eV	½
2-3-2	$E = -1.52 + 3.03 = 1.51$ eV $= 2.4 \times 10^{-19}$ J	
	$\lambda = 3 \times 10^8 \times 6.62 \times 10^{-34} / 2.4 \times 10^{-19} = 827.5$ nm	¾
2-4	The energy is absorbed and the atom become in the state E_2 since $-3.03 + 1.09 = -1.94$ eV $= E_2$ (second excited state)	1
2-5-1	$E_{photon} = hc/\lambda = 6.86 \times 10^{-19}$ J $= 4.29$ eV	½
	$E_0 + E_{photon} = -5.14 + 4.29 = -0.85$ eV $= E_5$, the atom, in its ground state, absorbs the energy of the photon and becomes in the fifth excited state	½
2-5-2	$KE = E_0 + 6$; $KE = 6 - 5.14 = 0.86$ eV	½

Exercise 2 (7 Points)   Compound Pendulum

Question	Answer	Mark
1-1-1	$(M+m)\overrightarrow{AG} = M\overrightarrow{AO} + m\overrightarrow{AC}$. All the vectors have the same direction: $(M+m)AG = M \ AO + m \ AC$.	
	$(M+m)a = M \ L/2 + m \ x$.	
	$AG = a = \frac{mx + ML/2}{(m+M)} = \frac{2mx + ML}{2(m+M)}$	½
1-1-2	$I = I_{rod} + mx^2 = ML^2/3 + mx^2 = (ML^2 + 3mx^2)/3$	½
1-1-3	$M.E = K.E + P.E_P = \frac{1}{2} I \theta'^2 - (m+M)g.a.\cos\theta$	½
1-1-4	$M.E = constant \Rightarrow dM.E/dt = 0$; $I.\theta'.\theta'' + (m+M).g.a.\theta'.\sin\theta = 0$; $\sin\theta = \theta$ (for small angles) ; $\theta' \neq 0$; $\theta'' + \frac{(m+M).g.a}{I}.\theta = 0$	1

1-1-5	$\theta = \theta_m \cos(\omega_o t + \varphi)$; $\theta' = -\theta_m \omega_0 \sin(\omega_o t + \varphi)$; At $t = 0$; $0 = -\theta_m \omega_0 \sin(\varphi)$; $\varphi = 0$ or $\varphi = \pi$ rd $\theta_o = \theta_m \cos\varphi > 0$ so ;$\varphi = 0$ accepted ; replace for $\varphi = 0$ to get $\theta_m = 8\pi/180 = 0.14$ rad so: $\theta = 0.14 \cos(\omega_o t)$	1
1-1-6	$T = 2\pi/\omega_0 = 2\pi\sqrt{I/(M+m)ga} = 2\pi\sqrt{(3x^2 + 2.4)/[(30)(1.2+x)]}$	½
1-2-1	$I_1 = I_{rod} + m \times OC^2 = ML^2/12 + m(L/2 - x)^2$ $= 0.1 + 0.5(0.5-x)^2$. $I_2 = ML^2/12 + m(L/2)^2 = 0.225$ kgm^2	½ ½
1-2-2	Forces acting are : $m\vec{g}$; $M\vec{g}$; reaction of the axis $\vec{R}$; The sum of the moments of these forces with respect to the axis (Δ) is zero $\sum M = 0$; so angular momentum is conserved. Then $\sigma_i = \sigma_f$; $I_1\theta'_1 = I_2\theta'_2$ $[0.1 + 0.5(0.5-x)^2]2 = [0.225]1.5$ $x = 0.13$m or $x = 0.87 > 0.5$ rejected	½ ½ ½
1-2-3	subs. x =0.13m in $T_o = 2\pi\sqrt{(3x^2 + 2.4)/[(30)(1.2+x)]}$ to get $T_0 = 1.5$ sec.	½

Exercise 3 (6½ points)   Aspect of Light

Question	Answer	Mark
1-1	We observe on the screen at O a bright fringe since S_1 and S_2 are in phase, so the light issued from S_1 and that issued from S_2 reach O in phase because $S_1O = S_2O$ $\Rightarrow \delta = 0$. (k = 0).	½
1-2	Straight , parallel, equidistant and alternating bright and dark fringes	½
1-3	The superposition of the two light beams emitted by the sources S_1 and S_2 gives rise to an interference phenomenon	¾
1-4	$\delta = \dfrac{ax}{D}$	¼
1-5	For the center of the dark fringes, we have $\delta = (2k+1)\lambda/2$. We get $\dfrac{ax}{D} = (2k+1)\lambda/2$, so $x = (2k+1)\dfrac{\lambda D}{2a}$.	½
1-6	The inter-fringe distance is the distance between the centers of two consecutive fringes of same nature. $i = x_{k+1} - x_k = \dfrac{(2k+3)\lambda D}{2a} - \dfrac{(2k+1)\lambda D}{2a} = \dfrac{\lambda D}{a}$	½ ½
1-7	x = 3.75mm = 3.75×10^{-3}m M $\in$ to bright fringe if $\delta = k\lambda$ and k belong to N So ax/ D = kλ k= ax/Dλ = 6 (6TH bright fringe) $\delta = \dfrac{ax}{D} = (10^{-3} \times 3.75 \times 10^{-3})/1 = 3.75 \times 10^{-6}$m. So $\dfrac{\delta}{\lambda} = (3.75 \times 10^{-6})/(0{,}625 \times 10^{-6}) = 6$, so M is the center of a bright fringe.	½ ½

1-8	In the central fringe, we have $\delta = 0$. $\frac{a\,x}{D} = e(n-1)$ but $x = 3i/2 = 9.375 \times 10^{-4}$m and $i = \frac{a\,x}{D(n-1)}$ Replace: $e = 1.875 \times 10^{-6}$ m	½
2-1	$a = 10^{-3}$m The light undergoes the phenomenon of diffraction.	½
2-2-1	$L = \dfrac{2\lambda D}{a}$	¼
2-2-2	$L = \dfrac{2 \times 625 \times 10^{-9} \times 1}{0.1 \times 10^{-3}} = 0.0125\,\text{m} = 12.5\,\text{mm}$	¼
2-3	It is the wave aspect of light.	½

Exercise 4 (7½ points)　　　　Determination of the characteristics of electric components

Question	Answer	Mark
1-1	Current Resonance phenomenon	¼
1-2	$f_0 = 200$ Hz	¼
1-3	$R = \dfrac{U}{I_0} = \dfrac{21}{0.14} = 150\ \Omega$	½
1-4	$f_0 = \dfrac{1}{2\pi\sqrt{LC}}$ $LC = 0.625 \times 10^{-6}\ \text{s}^2$ (equation 1)	½
2-1-1	$U_m = S_v \times y = 20\text{V}$	½
2-1-2	The waveform displayed on channel Y_2 leads that displayed on channel Y_1 since the voltage u_{AM} takes the maximum value before the voltage u_{DM}, both varying in the same sense. One period extends over D = six divisions and the phase difference corresponds to d = one division, so: $\phi = 2\pi\left(\dfrac{d}{D}\right) = 2\pi\left(\dfrac{1}{6}\right) = \dfrac{\pi}{3}\,\text{rad}$ $\omega_0 = 2\pi f = 100\pi\,\text{rad}/\text{s}$ $U_{m2} = S_v \times y_2 = 10$ V $u_{DM} = 10 \sin(100\,\pi t + \pi/3)$ (u_{DM} in V, t in s)	½ ½ ½
2-1-3	$i = \dfrac{u_{DM}}{R} = \dfrac{10}{150}\sin(100\pi t + \dfrac{\pi}{3})\ \Rightarrow$ $i = 0.067\sin(100\pi t + \dfrac{\pi}{3})$ (i in A, t in s)	½
2-2-1	$u_{AB} = u_C;$ $u_C = \dfrac{1}{C}\int i\ dt = -\dfrac{0.066}{100\pi C}\cos(100\pi t + \dfrac{\pi}{3})$	¾
2-2-2	$u_L = L\dfrac{di}{dt} = 6.7\,\pi L\,\cos(100\pi t + \dfrac{\pi}{3})$	¾

2-2-3	$u_{AM} = u_{AB} + u_{BD} + u_{DM}$ $20\sin(100\pi t) =$ $-\dfrac{0.067}{100\pi C}\cos(100\pi t + \dfrac{\pi}{3}) + 6.7\pi L\cos(100\pi t + \dfrac{\pi}{3}) + 10\sin(100\pi t + \dfrac{\pi}{3})$ For $t = 0$ $0 = -\dfrac{0.067}{100\pi C}\cos(\dfrac{\pi}{3}) + 6.7\pi L\cos(\dfrac{\pi}{3}) + 10\sin(\dfrac{\pi}{3})$ $0 = -\dfrac{0.067}{200\pi C} + 3.3\pi L + 10\dfrac{\sqrt{3}}{2}$ we get: $\Rightarrow$ $3.3\pi^2 LC + 5\pi\sqrt{3}\,C = \dfrac{0.067}{200}$ (equation 2)	1
2-3	Substitute equation (1) in equation (2) we get: $\begin{cases} C = 1.13\times10^{-5}\,F = 0.113\mu F \\ \quad L = 0.054H = 54\ mH \end{cases}$	1