LEBANESE UNIVERSITY

FACULTY OF ENGINEERING

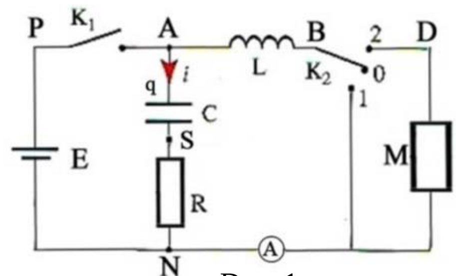
الجامعة اللبنانية
كلية الهندسة

Entrance exam 2017-2018 **July 2017**

Physics **Duration 2 h**

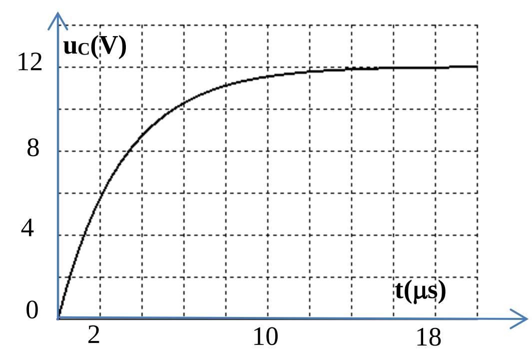
Exercise I: Capacitor, Humidity Sensor (15 pts)

The adjacent electric set (Doc. 1) is carried out where $E = 12$ V, L is a constant and $R = 20\ \Omega$.



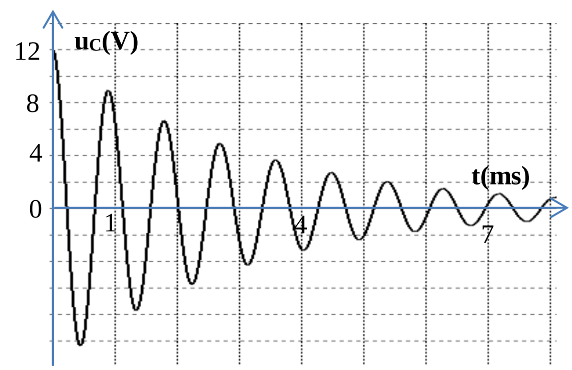
Doc. 1

1. Switch (K_2) is in position 0; Switch K_1 is closed. The graph in Doc.2 represents the variation of the voltage $u_C = u_{AS}$ across the capacitor as a function of time.
Determine graphically (Doc. 2) the time constant of the (R, C) series circuit and show that the capacitance C of the capacitor is C = 150 nF.



Doc. 2

2. Switch K_1 is now open; Switch K_2 is put in position 1. The graph in Doc.3 shows the variation of u_C as a function of time.
2.1. Derive the differential equation in u_C.
2.2. Determine graphically the pseudo-period T.
2.3. Deduce, with justification, the value of the inductance L of the coil.



Doc.3

3. The capacitor is charged again and the switch K_2 is placed in position 2 at an instant chosen as a new origin of time. The voltage across the terminals of the electronic device (M) is $u_g = u_{DN}$.

3.1. For a certain adjustment of (M), u_C becomes of the form $u_C = E\cos(2\pi ft)$ with f the frequency of these oscillations. Specifying the role of the device, deduce the expression of u_g.
3.2. Determine the average power delivered by this device between the instants $t_0 = 0$ and $t_1 = 4T$.
3.3. Determine the expression of the current i carried by the circuit. Deduce that the amplitude I_m of i is given by $I_m = 2\pi f CE$.

4. The used capacitor is a humidity sensor whose capacitance C varies with the humidity rate H according to the relation:
$C = (aH + b)$ with C in nF and H in %. To determine the values of the constants a and b, the following two measurements are made

under the same conditions as those of the first measurement, the percentage of humidity being read on a hygrometer.

Measurement	H%	I_m(mA)	f(kHz)_	C
n°2	30.4	13.7	1.16	C_2
n°3	54.8	14.9	1.07	C_3

4.1. Determine the values of a and b.
4.2. Determine the percentage of humidity H during the first measurement.

Exercise II: Use of radioactive nuclei in medicine (15 pts)

Speed of light in vacuum c = 3.0×10^{8} m·s^{-1}; Planck's constant: h = 6.62×10^{-34} J·s; 1 eV = 1.6×10^{-19} J ; 1 u = 931.5 MeV/c^2 = 1.66×10^{-27} kg; radioactive constant of thallium 201 : $\lambda_{Tl} = 2.6\times10^{-6}$ s^{-1}.

Particle or nucleus	Hg 201	proton	neutron	electron
Mass in u	200.970 032	1.00728	1.00866	0.00055

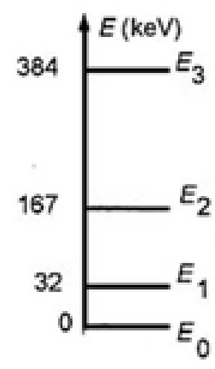
1. A thallium nucleus 201 is obtained by β^+ radioactive decay of a lead nucleus 201, itself obtained by bombarding a thallium 203 target with protons, according to the reaction:

$${}^{203}_{81}\mathrm{Tl} + {}^{1}_{1}\mathrm{H} \longrightarrow {}^{201}_{82}\mathrm{Pb} + y\,{}^{a}_{z}\mathrm{X}. \ (1)$$

1.1. Identify the particle (${}^{a}_{z}\mathrm{X}$) and calculate y.
1.2. Write the equation (2) of the decay of the lead nucleus 201 into a thallium nucleus 201. It will be assumed that the daughter nucleus is obtained in the ground state.

2. The thallium nucleus 201, having a binding energy per nucleon E_ℓ/A = 7.684 MeV/nucleon, absorbs an electron and transforms into a mercury nucleus (${}^{201}_{80}\mathrm{Hg}$) according to the equation:

$${}^{201}_{81}\mathrm{Tl} + {}^{0}_{-1}\mathrm{e} \longrightarrow {}^{201}_{80}\mathrm{Hg} + {}^{0}_{0}\nu + \gamma \ (3).$$



Doc.1

This nuclear reaction is accompanied by the emission of several photons, among which the photons γ_1 and γ_2 that are of respective energies W_1 = 135 keV and W_2 =167 keV.
Document 1 represents the energy diagram of the first levels of the mercury nucleus 201.
2.1. Represent on this diagram the transition corresponding to each of the two photons γ_1 and γ_2.
2.2. Calculate the values of the wavelengths λ_1 and λ_2, in vacuum, of the two photons γ_1 and γ_2.
2.3. Deduce the wavelength of the photon corresponding to the transition from level E_1 to level E_0.
2.4. Calculate, in MeV, the energy released by the nuclear reaction (3).

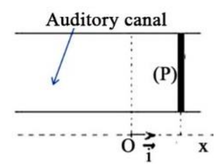
3. Thallium 201 is used in nuclear medicine to perform a diagnosis following heart pain. Examination of a 70 kg patient requires intravenous injection of a thallium chloride solution with an initial activity at $t_0 = 0$, $A_0 = 78$ MBq.

3.1. Calculate the number N_0 of thallium nuclei received by this patient at the instant of injection.

3.2. Since thallium has some toxicity, a limit energy absorbed per unit of body mass has been established. It is 15 $mg \cdot kg^{-1}$ (per unit of body mass). Check by a calculation that the energy absorbed per unit of body mass injected to the patient is safe.

3.3. It is believed that the results of the examination can be used as long as the activity of thallium 201 is greater than 3 MBq. Determine, in days, the time after which a new injection is necessary if we want to continue the examination to ensure the diagnosis.

Exercise III: Functioning of the eardrum of a human ear (30 pts)



Doc.1

The eardrum of a human ear, under certain conditions, can be modeled by a flat membrane (P), of mass $m = 1.5\times10^{-5}$ kg, which can oscillate, parallel to itself, on either side of its stable equilibrium position at O. The membrane (P), displaced from O in the positive direction by $x_0 = 10^{-9}$ cm, is released from rest at the instant $t_0 = 0$. At an instant t, (P), of abscissa x and of velocity $\vec{v} = v\,\vec{i}$ where $v = \frac{dx}{dt} = \dot{x}$, undergoes from the support of the eardrum a force $\vec{F}_1$ of expression $\vec{F}_1 = -kx\,\vec{i}$, where $k = 3500\ N\cdot m^{-1}$.

A- Any dissipative force is neglected.

1. Derive the differential equation in x that describes the motion of (P).

2. Determine the expression of the proper angular frequency ω_0 of the supposed ideal oscillations and calculate its value.

3. Determine the time equation of motion of (P) and deduce the expression of v as a function of time.

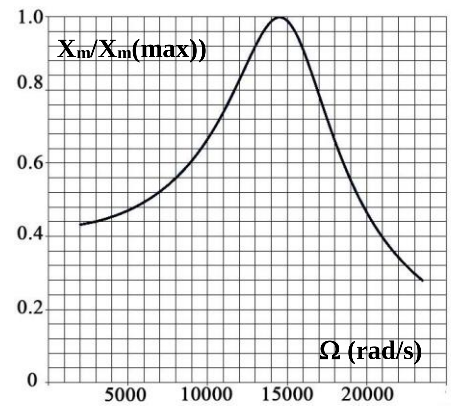
B- In fact, (P) undergoes, in addition to the force $\vec{F}_1$, a dissipative force $\vec{F}_2 = -h\vec{v}$, where $h = 0.10\ N\cdot s\cdot m^{-1}$.

1. Determine the differential equation in x that describes the motion of (P).

2. The motion of (P) is then pseudo-periodic of pseudo angular frequency ω'_0. Calculate its value knowing that: $(\omega'_0)^2 = (\omega_0)^2 - \delta^2$ where $\delta = \frac{h}{2\,m}$.

3. The solution of this differential equation is of the form: $x = x_0\, e^{-\delta t}[\cos(\omega'_0\, t) + \frac{\delta}{\omega'_0}\sin(\omega'_0\, t)]$. Show that the expression of v is: $v = -\frac{x_0\,\omega_0^2}{\omega'_0}\, e^{-\delta t}\sin(\omega'_0\, t)$.

4.1. Deduce the instant at which the eardrum becomes practically motionless.
4.2. Draw the shape of the curve $v = v(t)$ between the instants $t_0 = 0$ and $t = 2$ ms.



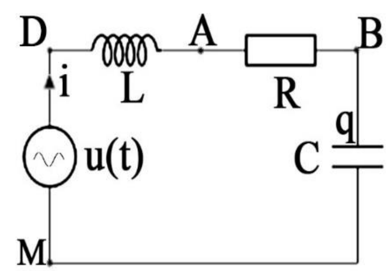
Doc. 2

C- A sound produces physically a change in pressure. Thus, the membrane (P) is now subjected to $\vec{F}_1$, $\vec{F}_2$, and to a pressure force $\vec{F}_3$ of expression $\vec{F}_3 = F_m \sin(\Omega t + \alpha)\,\vec{i}$, of adjustable frequency f, where $\Omega = 2\pi f$. In steady state, (P) performs forced oscillations of time equation: $x = X_m \sin(\Omega t)$.

1. Show that $\ddot{x} + \frac{h}{m}\dot{x} + \frac{k}{m}x = \frac{F_m}{m}\sin(\Omega t + \alpha)$

2. Show, by giving Ωt two particular values, that
$X_m = \frac{F_m}{\sqrt{h^2\Omega^2 + [k - m\Omega^2]^2}}$.

2.2. Document 2 shows the relative variation of X_m as a function of the angular frequency Ω, $X_m(\max)$ being the maximum value of X_m. Deduce the interval of the angular frequencies for which $X_m \geq \frac{X_m(\max)}{\sqrt{2}}$.



Doc.3

D- Electric analogy

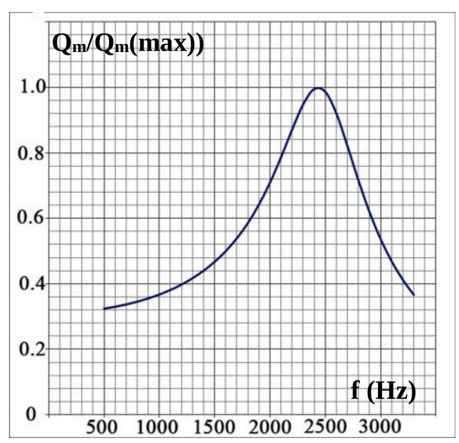
The eardrum membrane, preceded by the auditory canal, is modeled by the circuit of document 3, where L = 20 mH, R = 100 Ω and $u = U_m \sin(\omega t + \varphi)$ is an excitation voltage of adjustable angular frequency ω. The circuit then carries the current $i = I_m \sin(\omega t)$.

1. There is thus an electromechanical analogy. Express the same proper angular frequency ω_0 found in part (A-2) of this oscillator in terms of L and C and calculate the value of C.

2.1. Show, by applying the law of addition of voltages and giving ωt two particular values, that the amplitude Q_m of the charge q is:
$Q_m = \frac{U_m}{\sqrt{R^2\omega^2 + (L\omega^2 - \frac{1}{C})^2}}$.

2.2. Deduce the expression of the maximum value $Q_m(\max)$ of Q_m.

3. Determine, referring to document 4, the frequency range for which $Q_m \geq \frac{Q_m(\max)}{\sqrt{2}}$.



Doc. 4

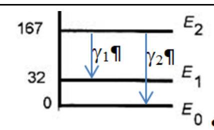
Entrance exam 2017-2018 **July 2017**

Physics Solution **Duration 2 h**

Exercise I: Capacitor, humidity sensor

Q		Note
1.	The time constant : $u_C(\tau) = 0.63\times12 = 7.56$ V$\Rightarrow \tau = 3.0$ μs $= 3.0\times10^{-6}$ s. The capacitance C of the capacitor. $\tau = R\cdot C \Rightarrow C = \tau/R = 3.0\times10^{-6}/20 = 1.50\times10^{-7}$ F. ou150 nF.	1 1
2.1	Law of addition of voltges: $u_{AS} + u_{SN} = u_{AB}$. $u_{AS} = u_C$. $i = \frac{dq}{dt} = C\frac{du_C}{dt}$ et $u_{SN} = RC\frac{du_C}{dt}$. $u_{AB} = -L\frac{di}{dt} = -LC\frac{d^2u_C}{dt^2}$. Thus, $u_C + RC\frac{du_C}{dt} = -LC\frac{d^2u_C}{dt^2}$. Therefore, $LC\ddot{u}_C + RC\frac{du_C}{dt} + u_C = 0 \Rightarrow$ $\ddot{u}_C + \frac{R}{L}\dot{u}_C + \frac{1}{LC}u_C = 0$.	2
2.2	4.5 pseudo-periods cover 4 ms, thus T = 4/4.5 = 0.89 ms	1
2.3	The damping is weak, then $T_0 \approx T = 0.89$ ms $= 2\pi\sqrt{LC} \Rightarrow L = 0.133$ H	1 ½
3.1	As oscillations become undamped, then the role of the device is to sustain oscillations, to compensate the losses due to Joule's effect: $u_g = u_{DN} = u_{SN} = +Ri$.	1 ½
3.2	The average power : $P_m = \frac{\Delta W_{C(max)}}{\Delta t} = \frac{½C(u_0^2 - u_4^2)}{4T} = \frac{½150\times10^{-9}(144-3.8^2)}{4\times0.89\times10^{-3}} = 2.73\times10^{-3}$ W.	2 ½
3.3	$i = C\frac{du_C}{dt} = -CE2\pi f\sin(2\pi ft)$, thus the amplitude of i is $I_m = CE2\pi f$.	1
4.1	The capacitance C is given by: $C = \frac{I_m}{2\pi fE}$ For the second measurement: $C_2 = \frac{13.7\times10^{-3}}{2\pi\times1.16\times10^3\times12} = 1.57\times10^{-7}$ F ou 157 nF. For the third measurement: $C_3 = \frac{14.9\times10^{-3}}{2\pi\times1.07\times10^3\times12} = 1.85\times10^{-7}$ F ou 185 nF. As C = aH + b Then, 157 = 30,4 a + b et 185 = 54.8 a + b $\Rightarrow$ 185 – 157 = (54.,8 -30.4) a $\Rightarrow$ a = 1.15 nF·%$^{-1}$. b = (185 -54.8)×1.15 = 122 nF	2 ½
4.2	$H = \frac{C-b}{a} = \frac{150-122}{1.15} = 24.3\%$.	1
		15

Exercise II: Use of radioactive nuclei in medicine

Q		Note
1.1	Law of conservation of the charge number: $81 + 1 = 82 + y \cdot z \Rightarrow yz = 0$. The only possibility is that $z = 0$. Then ${}^{a}_{z}X$ is a neutron with $a = 1$. Law of conservation of the mass number: $203 + 1 = 201 + y \cdot 1 \Rightarrow y = 3$.	1½
1.2	${}^{201}_{82}Pb \longrightarrow {}^{201}_{81}Tl + {}^{0}_{+1}e + {}^{0}_{0}\nu$ (2)	½
2.1	$W_1 = 135$ keV corresponds to the transition $E_2 \to E_1$ since $E_2 - E_1 = 167 - 32 = 135$ keV $W_2 = 167$ keV corresponds to the transition $E_2 \to E_0$ since $E_2 - E_0 = 167$ keV. 	1 ½ ½
2.2	$W_1 = 135\,000 \times 1.6 \times 10^{-19} = 2.16 \times 10^{-14}$ J ; $\boldsymbol{\lambda_1 = hc/W_1} = 6.62 \times 10^{-34} \times 3.0\ 10^{8}/2.16 \cdot 10^{-14} = \mathbf{9.19\ 10^{-12}\ m}$. $W_2 = 167\,000 \times 1.6 \times 10^{-19} = 2.67 \times 10^{-14}$ J ; $\boldsymbol{\lambda_2 = hc/W_2} = 6.62 \times 10^{-34} \times 3.0\ 10^{8}/2.67 \cdot 10^{-14} = \mathbf{7.44\ 10^{-12}\ m}$.	2
2.3	$W_2 - W_1 = W_3 \Rightarrow hc/\lambda_2 - hc/\lambda_1 = hc/\lambda_3 \Rightarrow 1/\lambda_2 - 1/\lambda_1 = 1/\lambda_3 \Rightarrow 1/7.44 - 1/9.19 = 0.0256 \Rightarrow \boldsymbol{\lambda_3 = 39.1 \times 10^{-12}\ m.}$	1 ½
2.4	$m(Tl) = 81m_p + 120m_n - 201 \times E_{\ell/A} \times 931.5 = 81 \times 1.00728 + 120 \times 1.00866 - (201 \times 7.684/931.5) = 200.970819$ u. $E_{lib} = [m(Tl) + m(e^-) - m(Hg)] \times 931,5$ $E_{lib} = (200.970819 + 0.00055 - 200.970032) \times 931.5 = 0.00134 \times 931.5 = 1.245$ MeV.	2 ½
3.1	$A_0 = \lambda_{Ti} \times N_0 \Rightarrow N_0 = A_0/\lambda_{Ti} = 78 \times 10^{6}/2.6 \times 10^{-6} = 3.0 \times 10^{13}$ noyaux	1
3.2	The injected mass: $m_0 = N_0 \times m(Tl) = 3.0 \times 10^{13} \times 201 \times 1.66 \times 10^{-27} = 1.0 \times 10^{-11}$ kg ou $m_0 = 1.0 \times 10^{-5}$ mg. Dose is: $1.0 \times 10^{-5}/70 = 1.43 \times 10^{-7}$ mg/kg < à 15 mg/kg.	2
3.3	Law of radioactive decay is: $A = A_0 e^{-\lambda t}$; $3 = 78\exp(-2.60 \times 10^{-6} t)$; $\ln(26) = -2.60 \times 10^{-6}\ t \Rightarrow$ The time, at the end of which a new injection is necessary: $t = 1.25 \times 10^{6}$ s = 14.5 days.	2
		15

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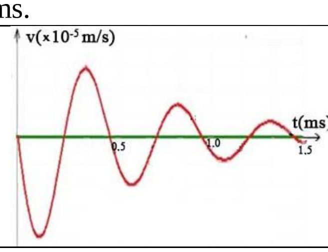
Exercise III: Functioning of the eardrum of a human ear

Q		Note
A.1	Mechanical energy of the system : ME = $\frac{1}{2} mv^2 + \frac{1}{2} kx^2$ = constant $\forall$ t. $\frac{dME}{dt} = mv\dot{v} + kx\dot{x} = 0$ avec $v = \dot{x} \neq 0 \Rightarrow$ The differential equation in x : $\ddot{x} + \frac{k}{m} x = 0$	2
2	The solution of the differential equation is of the form : $\ddot{x} + \omega_0^2 x = 0$. By identification : $\omega_0^2 = \frac{k}{m}$ and the expression of the proper angular frequency ω_0 is : $\omega_0 = \sqrt{\frac{k}{m}}$ therefore its value is$\omega_0 = \sqrt{\frac{3500}{1.5\times10^{-5}}} = 1.53\times10^4$ rad/s.	2
3.	The time equation of motion of (P) is of the form : x= A cos (ω_0t + φ) with $\dot{x} = -A\omega_0 \sin(\omega_0 t + \varphi)$. At $t_0 = 0$, $v = \dot{x} = -A\omega_0 \sin(\varphi) = 0 \Rightarrow \varphi = 0$ or π rad. At $t_0 = 0$, $x = x_0 = A \cos(\varphi) > 0$ and $A > 0$. For $\varphi = 0$, $A = x_0 > 0$ to be considered and foe $\varphi = \pi$, $A = -x_0 < 0$ to be rejected. Thus, $x = x_0\cos(1{,}53\times10^4\, t)$ x in m and t in s. The expression of the velocity v is $v = \dot{x} = -1{,}53\times10^4\, x_0 \sin(1{,}53\times10^4\, t)$ v in m/s and t in s.	2 1 ½
B.1	$\frac{dME}{dt} = mv\dot{v} + kx\dot{x} = P(\vec{F}_2) = -hv^2$; with $v = \dot{x} \neq 0 \Rightarrow$: $m\ddot{x} + k\,x = -h\,\dot{x}$. $\Rightarrow$ The differential equation in x that describes the motion of (P) is: $\ddot{x} + \frac{h}{m}\dot{x} + \frac{k}{m} x = 0$	1 ½
2	We have: $(\omega'_0)^2 = (\omega_0)^2 - \delta^2$ with $\delta = \frac{h}{2\,m}$. Thus, $\delta = \frac{0{,}1}{2\times1.5\times10^{-5}} = 3.33\times10^3$ rad/s. Therefore : $(\omega'_0)^2 = (1.53\times10^4)^2 - (3.33\times10^3)^2 \Rightarrow \omega'_0 = 1.49\times10^4$ rad/s.	2
3	$x = x_0 e^{-\delta t} [\cos(\omega'_0\, t) + \frac{\delta}{\omega'_0} \sin(\omega'_0\, t)]$. $v = \frac{dx}{dt} = x_0 e^{-\delta t} [-\delta\cos(\omega'_0\, t) - \frac{\delta^2}{\omega'_0} \sin(\omega'_0\, t) - \omega'_0 \sin(\omega'_0\, t) + \delta\cos(\omega'_0\, t)]$. $V = -\frac{x_0\,\omega_0^2}{\omega'_0} e^{-\delta t} \sin(\omega'_0\, t)$	1 ½
4.1	$V_{max} = \frac{x_0\,\omega_0^2}{\omega'_0} e^{-\delta t} = \frac{10^{-9}\times2.33\times10^8}{1{,}49\times10^4} e^{-3300t} = 1{,}56\times10^{-7} e^{-3330t}$ (V in m/s and t in s) The time constant: $\tau = 1/3330 = 3.0\times10^{-4}$ s. It stops after $5\tau = 1.5\times10^{-3}$ s or 1.5 ms.	2
4.2	$T'_0 = 0.42$ ms, $V_{max} = 1.56\times10^{-5}$ m/s et $5\tau = 1.5$ ms.  	2
C.1	$\frac{dME}{dt} = mv\dot{v} + kx\dot{x} = P(\vec{F}_2) + P(\vec{F}_3) = -h\dot{x}^2 + F_m \sin(\Omega t + \alpha)\dot{x}$ with $v = \dot{x} \neq 0 \Rightarrow$ $m\ddot{x} + k\,x + h\,\dot{x} = F_m \sin(\Omega t + \alpha)$. Thus, $\ddot{x} + \frac{h}{m}\dot{x} + \frac{k}{m} x = \frac{F_m}{m} \sin(\Omega t + \alpha)$	2
2.1	With $\dot{x} = X_m\,\Omega \cos(\Omega t)$ and $\ddot{x} = -X_m\,\Omega^2 \sin(\Omega t)$. $-X_m\,\Omega^2 \sin(\Omega t) - \frac{h}{m} X_m\,\Omega \cos(\Omega t + \varphi) + \frac{k}{m} X_m \sin(\Omega t) = \frac{F_m}{m} \sin(\Omega t + \alpha)$. For $t = 0 \Rightarrow \frac{h}{m}\Omega X_m = \frac{F_m}{m}\sin(\alpha) \Rightarrow \frac{F_m}{m}\sin(\alpha)$. For $\Omega t = \pi/2 \Rightarrow -X_m\,\Omega^2 + \frac{k}{m} X_m = \frac{F_m}{m}\cos(\alpha)$ $\frac{F_m^2}{m^2} = X_m^2\{\frac{h^2\Omega^2}{m^2} + [\frac{k}{m} - \Omega^2]^2\} \Rightarrow X_m = \frac{F_m}{\sqrt{h^2\Omega^2 + [k - m\Omega^2]^2}}$	2 ½
2.2	The angular frequency interval for which $X_m \leq \frac{X_m(max)}{\sqrt{2}}$ is for 10500 rad/s $\leq \Omega \leq$ 17800 rad/s.	1 ½

D.1	$\omega_0 = \sqrt{\frac{1}{LC}} = 1.53\times10^4$ rad/s. $\Rightarrow LC = 2.34\times10^8 \Rightarrow C = \frac{1}{20\times10^{-3}\times2.34\times10^8} = 2.14\times10^{-7}$ F.	1 ½
2.1	$i = I_m\sin(\omega t)$. Then : $u_{DA} = L\frac{di}{dt} = L\omega I_m\cos(\omega t)$ $u_{AB} = Ri = R\,I_m\sin(\omega t)$. $i = C\frac{du_{BM}}{dt} \Rightarrow u_{BM} = \frac{1}{C}\int i\,dt$ constant. Constant = 0 since u_{BM} is alternating sinusoidal. Thus, $u_{BM} = -\frac{1}{C\omega}I_m\cos(\omega t)$ Law of addition of voltages : $U_m\sin(\omega t+\varphi) = L\omega I_m\cos(\omega t) + R\,I_m\sin(\omega t) - \frac{I_m}{C\omega}\cos(\omega t)$. For $\omega t = 0 \Rightarrow U_m\sin(\varphi) = L\omega I_m - \frac{I_m}{C\omega}$. For $\omega t = \frac{\pi}{2} \Rightarrow U_m\cos(\varphi) = R\,I_m$. Therefore : $U_m^2 = I_m^2[R^2 + (L\omega - \frac{1}{C\omega})^2]$. Thus, $I_m = \frac{U_m}{\sqrt{R^2+(L\omega-\frac{1}{C\omega})^2}}$. As $u_{BM} = -\frac{1}{C\omega}I_m\cos(\omega t)$, then $Q_m = \frac{I_m}{\omega} = \frac{U_m}{\omega\sqrt{R^2+(L\omega-\frac{1}{C\omega})^2}} = \frac{U_m}{\sqrt{R^2\omega^2+(L\omega^2-\frac{1}{C})^2}}$.	3
2.2	$Q_m = \frac{U_m}{\sqrt{R^2\omega^2+(L\omega^2-\frac{1}{C})^2}}$; Q_m maximum for $\frac{dQ_m}{d\omega} = 0 \Rightarrow 2R^2\omega + 2(L\omega^2 - \frac{1}{C})(2L\omega) = 0$; $R^2 + 2(L\omega^2 - \frac{1}{C})(L) = 0 \Rightarrow R^2 + 2L^2\omega^2 - \frac{2L}{C}) = 0 \Rightarrow \omega_r^2 = \omega_0^2 - \frac{R^2}{2L^2}$ with $\omega_0^2 = \frac{1}{LC}$. $Q_m(max) = \frac{U_m}{\sqrt{R^2\omega_0^2-\frac{R^4}{L^4}+(L\omega_0^2-\frac{R^2}{2L}-\frac{1}{C})^2}} = \frac{U_m}{\sqrt{R^2\omega_0^2-\frac{R^4}{4L^2}}}$.	2 ½
3	The interval of frequencies for which $Q_m \le \frac{Q_m(max)}{\sqrt{2}}$ is 2000 Hz $\le f \le$ 2800 Hz.	1 ½
		30