國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學【光電所碩士班】　　題號：435001

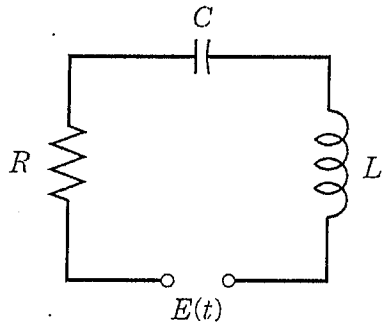
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. Solve the IVP. Show the steps of derivation, beginning with the general solution. (10 points)
   $y' = -4x/y$, $y(2) = 3$

2. Find a real general solution. Show the details of your work. (10 points)
   $xy'' + 4y' = 0$

3. Is the given function below linearly dependent or independent on the half-axis $x \geq 0$? Give reason. (15 points)
   $e^{-x}\cos x,\ e^{-x}\sin x, e^{-x}$

4. Using the Laplace transform to solve RLC-circuit problems. Find the current E(t) in the circuit, assuming zero initial current and charge. (25 points)



   R = 2Ω, L = 1H, C = 0.5 F, E(t) = 1 kV if $0 < t < 2$ and 0 if $t > 2$.

5. Find (a) the Fourier cosine series (8 points), (b) the Fourier sine series. (7 points)
   $f(x) = \sin x$ ($0 < x < \pi$)

6. By the principles used in modeling the string it can be shown that small free vertical vibrations of a uniform elastic beam are modeled by the fourth-order PDE.

$$\frac{\partial^2 u}{\partial t^2} = -c^2 \frac{\partial^4 u}{\partial x^4}$$

   (a) find solutions $u_n = F_n(x)G_n(t)$ corresponding to zero initial velocity and satisfying the boundary conditions: $u(0,t) = 0$, $u(L,t) = 0$, $u_{xx}(0,t) = 0$, $u_{xx}(L,t) = 0$ (12 points)
   (b) find the solution that satisfies the conditions in (a) as well as the initial condition: $u(x,0) = f(x) = x(L - x)$. (13 points)

國立中山大學103學年度碩士暨碩士專班招生考試試題

科目名稱：電磁學【光電所碩士班】　　題號：435002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

一、　填充題：每格5分，a~o共十五格，占75分

1. 考慮一個非均勻半徑為r之帶電球體，其電荷分佈在半徑R小於等於r時為 $\rho_0\left(1-\frac{R^2}{r^2}\right)$，其餘地區為0。請問球內總電荷為__a__、球內電場分佈為__b__。
2. 接上題，若改為均勻帶電球體，此時之電荷分佈為ρ_0，請問球外靜電場分佈為__c__、電位分佈為__d__。
3. 點電荷＋Q，放於大內外半徑分別是a、b且介電係數為ε的球型介電球殼，請問離球心距r為a到b的介電材料範圍中的電場E為__e__、極化相量P為__f__。另外，請問體積電荷密度ρ_{pv}為__g__。
4. 考慮兩個大小相同半徑為r金屬球距離d遠大於r，其球間電容為__h__。
5. 面積為A，相距為d的平行板電容其電壓充電到V能儲存的電位能__i__。
6. 半徑a之接地金屬球與距其球心距b(註：b>a)之電荷Q之間吸引力為__j__。
7. 在自由空間中，一個半徑a之金屬球放在方向為z軸之電場E所感應出之diople moment為__k__、電位為__l__。
8. 半徑為a、面電荷密度是均勻且值為ρ_s之圓盤，若以ω角速度旋轉，請問圓盤中心的磁通密度B_0為__m__。
9. 一條載有直流電流I得長直導線（半徑r、導電率σ），請問導線表面Poynting vector方向為__n__，大小為__o__。

二、　簡答與計算題；共兩題，共二十五分。

1. 試證明電磁波是橫波（5分）
2. 何謂肌膚深度(skin depth)？(5分)，為何有白銀與黃金的說法？(5分)，海水中用1MHz的電磁波其穿透深度為0.25公尺，若考慮深海（折射率1.5）探測攝影想利用綠光（於攝影機上且波長為500nm）觀測，若其容忍的衰減是30dB請問攝影機距探測目標最多多遠？（10分）

國立中山大學103學年度碩士暨碩士專班招生考試試題

科目名稱：近代物理【光電所碩士班選考】　　題號：435003

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

I. Questions: (60%)

1. Please show that the phase velocity and the group velocity of an electromagnetic wave propagating in free space are equal. (5%)
2. An electron and a proton are accelerated from rest through a total potential energy difference of 1.6×10^{-11} J. What is the increase in mass and final speed of each particle? (7%)
3. What is the threshold wavelength for a cathode material of 3.75 V stopping potential, if the incident light has a momentum of 3.32×10^{-27} kg·m/s? (7%)
4. What are the phase velocity and wavelength of a proton moving at a particle speed of (a) 10^2 m/s, and (b) 2×10^8 m/s? (7%)
5. An X-ray photon of 0.05 nm wavelength strikes a free, stationary electron. The photon scatters at 90°. Determine the momentum of the incident photon and the scattered photon. The Compton wavelength λ_C is 0.00243 nm. (5%)
6. An electron traveling at 8×10^6 m/s enters the region of the Thomson e/m_e apparatus where $\boldsymbol{E}$ and $\boldsymbol{B}$ fields coexist and are adjusted to be counter balancing. The $\boldsymbol{E}$ field is created by a parallel plate connected to a 91.1V battery and having a 6.4 cm plate separation. If the $\boldsymbol{E}$ field is deactivated, what is the radius of the electron's circular arc through the counter balancing magnetic field? (7%)
7. Using the generalized equations for the Bohr radii and Bohr velocities, please find the principal quantum number and translational speed of an electron encircling a single fixed proton with a 1 m radius. The Bohr radius is 0.53 Å. (5%)
8. A typical atomic nucleus is about 10^{-14} *m* in radius. What is the lower limit of the momentum of an electron must have if it is to be part of a nucleus? (5%)
9. Please tell the differences between fluorescence and phosphorescence of excited molecules. (5%)
10. Using the de Broglie's and Schrödinger's postulates together with the free particle wave function $\Psi(x,t) = Ae^{j(kx-\omega t)}$, please construct the Schrödinger's one dimensional time-dependent wave equation. (7%)

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II. Problems: (40%)

1. Assuming a cubic meter of hydrogen at 0°C and at atmospheric pressure satisfies Maxwell-Boltzmann statistics ($f_{MB}(\varepsilon) = Ae^{-\varepsilon/kT}$, where A is a constant, and T is ambient temperature). This system contains about 2.7×10^{25} atoms and the number of the atoms of energy ε within the system can be expressed by

$$n(\varepsilon) = g(\varepsilon) \times f_{MB}(\varepsilon),$$

where $g(\varepsilon)$ is number of states at energy ε and $f_{MB}(\varepsilon)$ is the probability of occupancy of the state at energy ε. Please find the number of these atoms in their first excited states (n = 2) at 0°C and at 10,000°C. The ground state energy of hydrogen atom is -13.6 eV. (20%)

2. Consider the time dependent Schrödinger equation for free particles moving in one dimension:

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} = i\hbar\frac{\partial\Psi}{\partial t}$$

The general solution of above equation can be given as: $\Psi(x,t) = A(p)e^{i(px-\varepsilon t)/\hbar}$

where $\varepsilon = p^2/2m$ is the nonrelativistic kinetic energy and p is the momentum. Assuming the normalized distribution function of the momentum is Gaussian and can be expressed as:

$$A(p) = \sqrt{\frac{\sigma}{2\pi\sqrt{\pi}\hbar^2}}\exp\left[\frac{-\frac{1}{2}\sigma^2(p-p_o)^2}{\hbar^2}\right]$$

where σ and p_o are the parameters of the Gaussian distribution. Please find the normalized wavefunction Ψ and Δx of the particles at t = 0. Note that $\int_{-\infty}^{\infty}\exp[-\frac{y^2}{a^2}+iby]dy = \sqrt{\pi}a\exp[-(\frac{ab}{2})^2]$ (20%)

Plank constant h = 6.626×10^{-34} J·s

Boltzmann constant k = 1.38×10^{-23} J/K

Velocity of light c = 300,000 Km/s

Electronic charge e = 1.6×10^{-19} C

Electron mass m_e = 9.1×10^{-31} kg

Proton mass M = 1.67×10^{-27} kg

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科目名稱：電子學【光電所碩士班選考】　　題號：435004

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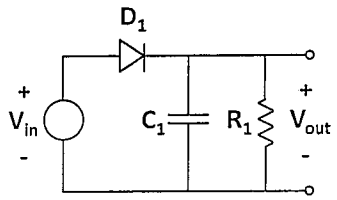
一、簡答題(40%)

1. (10%)請說明 pn 接面中空乏區(depletion region)的成因及空乏區寬度與雜質摻雜濃度、外加偏壓間的關係。
2. (10%)請說明 Early effect 的成因及其對 BJT 操作特性的影響。
3. (10%)請說明 Body effect 的成因及其對 MOS 操作特性的影響。
4. (10%)請畫出 MOS 的結構圖，並說明通道(channel)的產生原理。

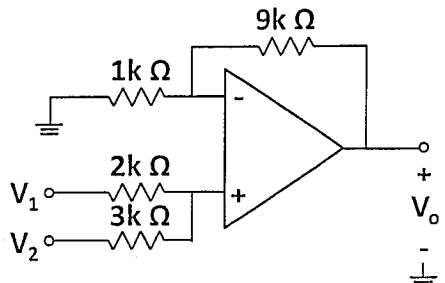
二、計算題(60%)

1. (10%)圖一為一常見的整流電路，電路中的二極體啟動電壓(turn-on voltage)為 0.8V，電路中的輸入電壓是一個正弦波(峰值>0.8V)，請將其輸出電壓(V_{out})波形與輸入電壓(V_{in})波形對時間作圖繪出。請討論此電路中電容(C_1)大小對其輸出電壓波形之影響。



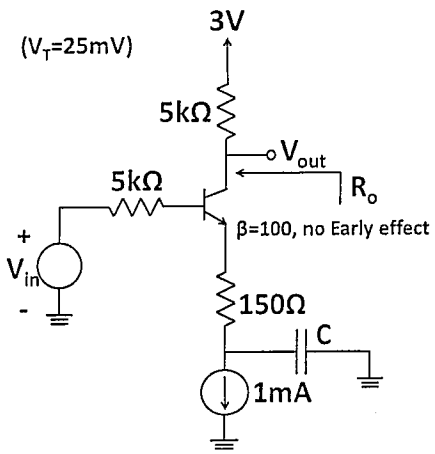
(圖一)

2. (10%)請推導出圖二電路的輸出電壓 V_o 與輸入電壓 V_1、V_2 間的關係。



(圖二)

3. (10%)請計算出圖三電路的放大增益($A_o=V_{out}/V_{in}$)與輸出阻抗(R_o)。



(圖三)

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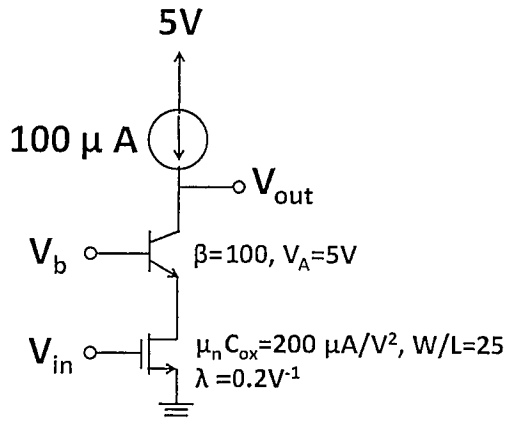
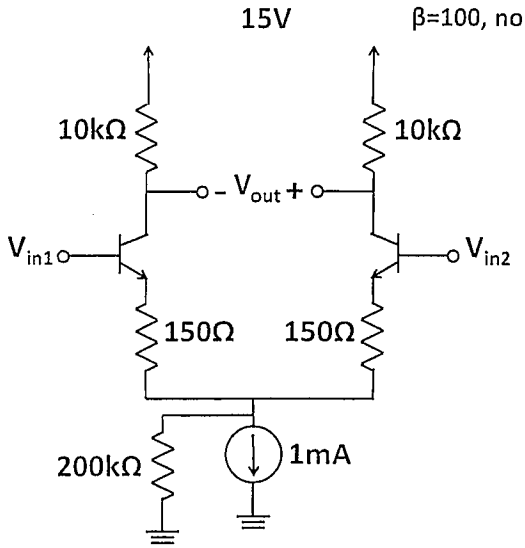
4.(10%)請計算出圖四電路中的放大增益($A_o=V_{out}/V_{in}$)與輸出阻抗(R_o)。



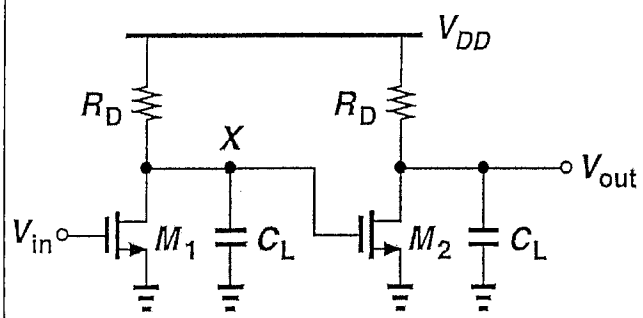
(圖四)

5.(10%)請求出圖五電路的差動電壓增益 $V_{out}/(V_{in1}-V_{in2})$。



(圖五)

6.(10%)請求出圖六電路的-3db bandwidth。



(圖六)