國立中山大學105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）（問答申論題）　　

1. (30%) The Nobel Prize in Physics 1921 was awarded to Albert Einstein *"for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect"*. Please answer the following questions.

(a) (10%) Please explain photoelectric effect clearly.

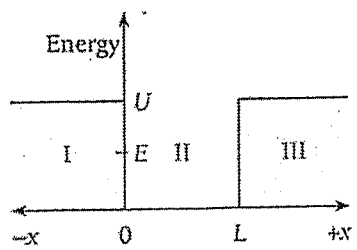
(b) (10%) How can photoelectric effect support the quantum theory of light?

(c) (10%) How can we find the work function of a metal utilizing photoelectric effect? (you should give some equations or illustrations to answer this question)

2. (20%)The Nobel Prize in Physics 1933 was awarded jointly to Erwin Schrödinger and Paul Adrien Maurice Dirac *"for the discovery of new productive forms of atomic theory"*

(a) (10%) Consider a particle in a potential well with square corners that is U high and L wide. The energy of the particle, E, is smaller than U. Please find the wave function of the particle.

(b) (10%) Is it possible to find the particle outside the potential well? Why?



3. (30%) The Nobel Prize in Physics 1964 was divided, one half awarded to Charles Hard Townes, the other half jointly to Nicolay Gennadiyevich Basov and Aleksandr Mikhailovich Prokhorov *"for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle"*.

(a) (10%) The term laser stands for "light amplification by stimulated emission of radiation". Please explain what the stimulated emission is. Please also tell the difference between stimulated emission and spontaneous emission.

(b) (10%) Please give some remarkable properties of laser (at least three).

(c) (10%) In a practical laser, at least 3-level energy states are needed. Please explain why two-level laser cannot be realized.

4. (20%)The Nobel Prize in Physics 1986 was divided, one half awarded to Ernst Ruska *"for his fundamental work in electron optics, and for the design of the first electron microscope"*, the other half jointly to Gerd Binnig and Heinrich Rohrer *"for their design of the scanning tunneling microscope"*. Please answer the following questions.

(a) (10%) How can electrons be used for microscopy?

(b) (10%) Please find the resolution of an electron microscope which emits 40-keV electrons.

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國立中山大學105學年度碩士暨碩士專班招生考試試題

科目名稱：電子學【光電所碩士班選考】　　題號：435004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　　

1. (20%) 關於 *pn* junction，請回答下列問題：
   (a) 請說明空乏區(depletion region)的成因，並描述 *pn* junction 在順向偏壓(forward bias)及逆向偏壓(reverse bias)的操作特性。(8%)
   (b) 請描述 *pn* junction 的電流表示式及畫出其 I/V curve。(6%)
   (c) 考慮圖 1 的電路圖，假設 D_1 與 D_2 的特性相同且 $I_S = 5\times10^{-16}$A，若要使流過電阻 R 的電流為 0.5mA，請問電阻 R 值必須為？(6%)

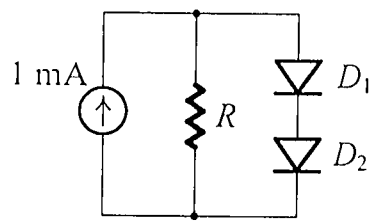

圖 1.

2. (16%) 關於 MOSFET，請回答下列問題：
   (a) 請畫出 MOSFET 的結構圖，並說明通道(channel)的產生原理。(8%)
   (b) 請畫出隨著通道長度的增加，I_D-V_G 及 I_D-V_D 特性圖的變化趨勢，並請解釋原因。(8%)

3. (16%) 關於 Bipolar Amplifier，請分別畫出 common-emitter 及 common-base 的基本結構，並比較兩者特性的差異。

4. (12%) 考慮圖 2 的電路，若 $V_A<\infty$，請求出 voltage gain 及 output impedance。

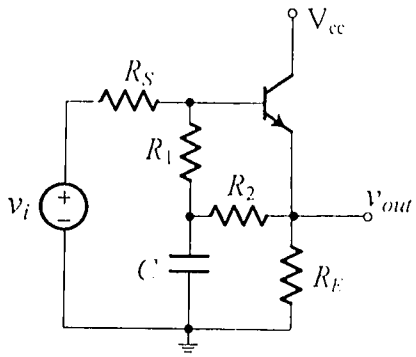

圖 2.

5. (12%) 假設 channel-length modulation coefficient $\lambda = 0$，請求出圖 3 電路之 transfer function 的絕對值表示式。

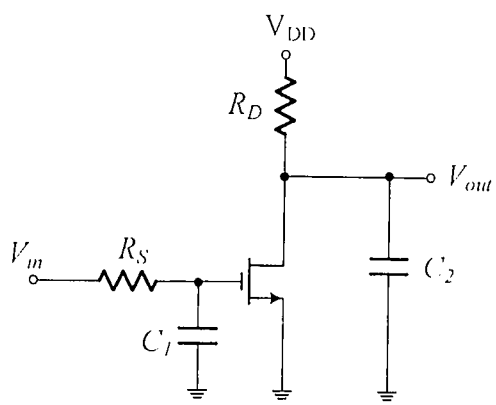

圖 3.

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6. (12%) 假設 A 為一理想 operational amplifier，請以 V_1 及 V_2 表示圖 4(a)及圖 4(b)之 V_O。

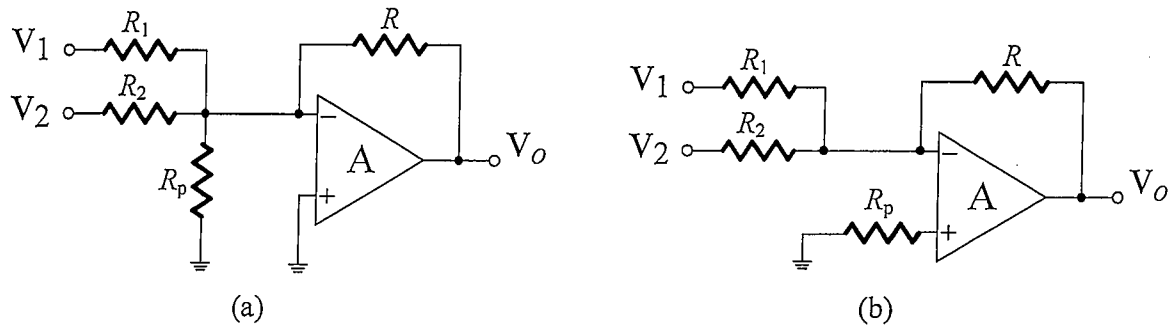

圖 4

7. (12%) 請求出圖 5 電路之電路增益(voltage gain)，假設 $V_A = \infty$。

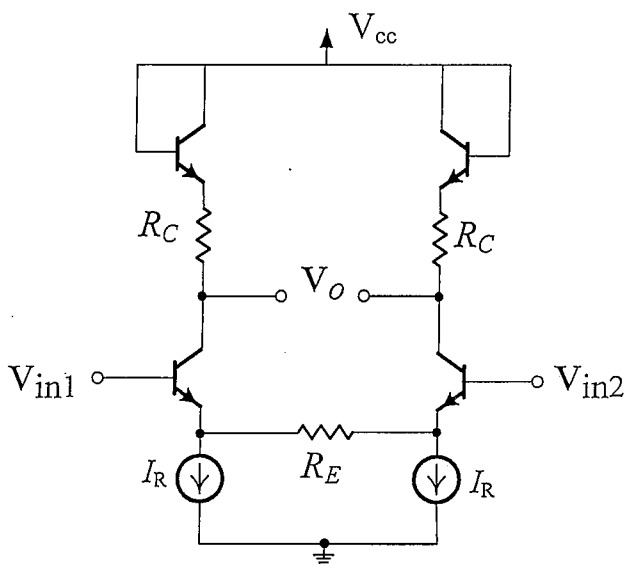

圖 5

國立中山大學105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）（問答申論題）　　

1. Please find a basis of eigenvectors and diagonalize. (15%)

$$A=\begin{bmatrix} 7.3 & 0.2 & -3.7 \\ -11.5 & 1.0 & 5.5 \\ 17.7 & 1.8 & -9.3 \end{bmatrix}$$

2. Please find the inverse Laplace transform of the function $\frac{-s+11}{s^2-2s-3}$. (15%)

3. Solve the nonhomogeneous Euler-Cauchy equation (15%)

$x^3y'''-3x^2y''+6xy'-6y=x^4\ln x$ (x>0)

4. Evaluate the integrals. (15%)

(a) $\int_0^{\pi/4}\int_0^{\cos y} x^2\sin y\,dxdy$　　(b) $\int_0^3\int_{-y}^{y}(x^2+y^2)\,dxdy$

5. Find the Fourier transform of the function f(x). (10 %)

$f(x)=xe^{-x^2}$

6. Please evaluate $\oint_C \frac{2z^3+z^2+4}{z^4+4z^2}dz$, C the circle $|z-2|=4$, clockwise. (15%)

7. Find the center and the radius of convergence (15%)

(a) $\sum_{n=0}^{\infty}\frac{n^n}{n!}(z-\pi i)^n$　　(b) $\sum_{n=1}^{\infty}\frac{3^n}{n(n+1)}z^{2n+1}$

試題隨卷繳回

國立中山大學105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）(問答申論題)　　共1頁第1頁

1. Please write down the names (in English) of the four fundamental electro-magnetic (EM) vector fields $\vec{E},\vec{D},\vec{B},\vec{H}$ and describe their physical and mathematical meanings respectively. You must clearly explain the physical and mathematical differences between $\vec{E},\vec{D}$ and $\vec{B},\vec{H}$. Also, explain why we need to use all four vector fields (rather than just two) in the EM theory. (20%)

2. Using gradient and divergent operators derive, step by step, derive the Laplacian operator applied to a scalar function $f(\rho,\phi,z)$ in the cylindrical coordinate system. Please also provide coordinate independent definitions of the gradient and the divergent operator. (20%)

3. With symmetry we may apply the Ampere's law to determine the magnetic field around a straight thin wire. This approach will not work for a current loop. Please describe how (and explain the required conditions to make it works) we may, mathematically, determine the electro-magnetic vector fields excited by a current loop carrying a slowly varying current. (10%)

4. A small current loop is often called a magnetic dipole even though there are no magnetic charges. Comparing physics and mathematics of an electric dipole please explain why we call it a magnetic dipole for a small current loop with a small radius. Is there a limitation of this model? (10%)

5. A time-harmonic plane wave is impinging obliquely on a plane boundary located at $z=0$ between two dielectric medium $\mu_1=\mu_2=\mu_0$. Here the plane of incident is the $x-z$ plane and the angle of incidence is θ_i. Determine the reflection and transmission coefficients $\Gamma_{\parallel}$, $\tau_{\parallel}$ of the plane wave which is parallely polarized (electric field is on this plane of incidence). The index of refraction of the incident and transmitted medium is n_1 and n_2 respectively. Please draw a diagram showing all propagation vectors and the corresponding field components of the incident, reflected and transmitted plane waves. (20%) Partial credit will be given to the simple normal incident case.

6. A perfectly conducting material (PCM) is assumed to have an infinite conductivity $\sigma=\infty$ therefor no time-varying EM field can exist inside the PCM. However, electric charges and current do exist on the surface of a PCM. Using just the Maxwell's equations and the fact that electric current $\vec{J}$ equals to $\sigma\vec{E}$, derive the boundary conditions of both the parallel and tangential $\vec{E}$ and $\vec{H}$ components on the surface of a PCM in the free space. (20%)

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