國立中山大學106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）（選擇題）　　共1頁第1頁

單選題,答錯不扣分,每題10分,共十題.

1. $A=\begin{bmatrix}0&1&0&0\\0&0&1&0\\0&0&0&1\\1&0&0&0\end{bmatrix}$, $A^{42}=?$

(A) $\begin{bmatrix}0&1&0&0\\1&0&1&0\\0&1&0&1\\0&0&1&0\end{bmatrix}$ (B) $\begin{bmatrix}0&1&0&0\\0&0&1&0\\0&0&0&1\\1&1&0&0\end{bmatrix}$ (C) $\begin{bmatrix}0&0&1&0\\0&0&0&1\\1&0&0&0\\0&1&0&0\end{bmatrix}$ (D) $\begin{bmatrix}0&1&0&1\\1&0&1&0\\0&1&0&1\\0&0&1&0\end{bmatrix}$ (E) $\begin{bmatrix}0&1&0&1\\1&0&1&0\\0&1&0&1\\1&0&1&0\end{bmatrix}$

2. The inverse Laplace transform of the function $\frac{3s-137}{s^2+2s+401}$ is $e^{At}(3cosBt-7sinBt)$, where
(A) A=-1, B=-20, (B) A=-1, B=20, (C) A=1, B=-20, (D) A=1, B=20, (E) A=2, B=30.

3. A general solution for the equation $y'''-6y''+11y'-6y=3x$ is $ae^x+be^{2x}+ce^{Ax}+\frac{x}{B}-\frac{11}{12}$, where (A) A=3, B=2,(B) A=3, B=-2, (C) A=3, B=3, (D) A=3, B=-2, (E) none of the above.

4. Evaluate the volume of the tetrahedron defined by four vertices (1,0,-1), (3,0,2), (1,6,1), (4,3,-1).
(A) 66, (B) 33, (C) 22, (D) 11, (E) none of the above.

5. The Fourier transform of the function $f(x)=xe^{-x^2}$ does not include
(A) 2, (B) 4, (C) 6, (D) ω, (E) ω^2.

6. Find the smallest positive integers m and n such that $(\sqrt{3}+i)^m=(1+i)^n$, where
(A) m=3, n=6, (B) m=6, n=12, (C) m=9, n=18, (D) m=12, n=24, (E) none of the above.

7. Integrate $\oint_C \frac{\tan z}{z^2-1}dz$ counterclockwise around the C: $|z|=\frac{3}{2}$. The integral is
(A) 2π, (B) 2πi, (C) 2π tan 1, (D) 2πi tan 1, (E) none of the above.

8. Find $\oint_c (x^2+2y)dx+(4x+y^2)dy$ where C is the circle $x^2+y^2=1$.
(A) 2π, (B) -2π, (C) 6π, (D) -6π, (E) none of the above.

9. The residue of the complex function $f(z)=(z+2)e^{\frac{1}{z}}$ at z=0 is
(A) 1/2, (B) 1, (C) 3/2, (D) 2, (E) 5/2.

10. Find the analytic function $f(z)=u(x,y)+iv(x,y), where\ v(x,y)=e^{-3x}\sin 3y$
(A) $-e^{-3z}$, (B) e^{-3z}, (C) $-e^{3z}$, (D) e^{3z}, (E) none of the above.

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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. An electromagnetic wave $\vec{E}_1$ is incident at the interface of two mediums with permittivities ε_1 and ε_2, as shown in Fig. 1. The angle of the incident wave in medium 1 is θ_1. Please find the direction and magnitude of the refractive wave $\vec{E}_2$. Consider now if $\varepsilon_2 = \varepsilon_{2r} + i\,\varepsilon_{2i}$, what will happen to $\vec{E}_2$? (15%)
2. Please draw the equipotentials and electric field lines of two oppositely charged (+Q, -q) spheres with a separation distance d. (10%)
3. Please find the potential distribution in the space between the conductors of a very long coaxial cable, as shown in Fig. 2. The inner conductor has a radius a and is kept at a constant potential V_o. The outer conductor has an inner radius b and in grounded. (10%)
4. Consider the charge distribution of a metal-oxide-semiconductor system under a specific bias condition, as shown in Fig. 3. Q_t is the total positive charge at the metal-oxide interface, Q_n is negative charge due to accumulation of electron at the oxide-semiconductor interface, and Q_d is the depletion charge caused by the field at the metal. Q_n can be considered as a two dimensional electron gas. Please draw the electric field and potential distribution of this system for $x > 0$. (15%)

Fig. 1

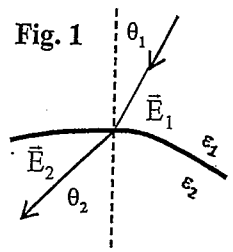


Fig. 2

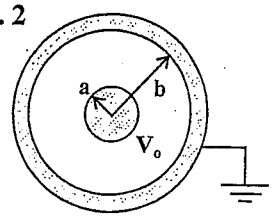
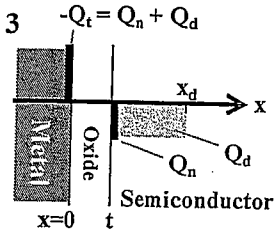


Fig. 3



5. Consider now a metal bar which is sliding with a constant velocity $\upsilon\,\hat{a}_x$ over a pair of metal rails in a uniform magnetic field $B\,\hat{a}_z$, as shown in Fig. 4. Please determine the open circuit voltage between terminals 1 and 2. If now frictions take place at both the metal rails causing the metal bar to deaccelerate with a constant acceleration velocity $-a\,\hat{a}_x$. Please find the open circuit voltage as a function of time. (15%)
6. Please find the magnetic field at point P beside a section of cable (from x = a to b) carrying a current I, as shown in Fig. 5. (10%)

Fig. 4

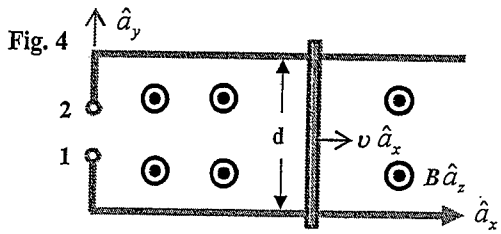
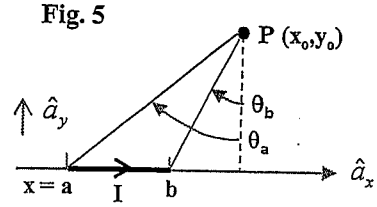


Fig. 5



7. A 5 GHz plane wave travels in free space with an electric field $E_x = 10$ V/cm. Please find the phase velocity, wavelength, and propagation constant. What is its magnetic field intensity? $\varepsilon_o = 8.854\times10^{-12}$ F/m and $\mu_o = 4\pi\times10^{-7}$ H/m. (10%)
8. Please find the potential distribution and electric field in the space above the conducting plane of infinite extent. Note that a point charge Q is positioned at a distance h above the conducting plane. Please also draw equipotentials and electric field lines above the conducting plane. (15%)

國立中山大學106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. (30%) 關於 Semiconductor 與 PN diode，請回答下列問題：
   (a) 請說明霍爾效應(Hall effect)，以及如何利用此效應判斷半導體材料為 P 型或 N 型。(4%)
   (b) 請說明一般 PN diode 與 Zener diode 的物理特性差異，在實際製作 Zener diode 時，其物理結構與一般 PN diode 有何不同。(6%)
   (c) 請說明 Zener breakdown 和 Avalanche breakdown 在物理機制上的差異。(6%)
   (d) 請說明為何 Zener diode 可以用於實現一電壓調整器(voltage regulator)。(6%)
   (e) 發光二極體(light emitting diode)與檢光器(photodiode)皆是由 PN diode 所實現，請說明這兩種元件的差異。(8%)

2. (14%) 關於 MOSFET，請回答下列問題：
   (a) 請畫出 PMOSFET 和 NMOSFET 利用實際晶圓廠製程所實現之的物理結構剖面圖，假設晶圓廠使用的矽基板為 P 型基板。(4%)
   (b) 請說明為何 NMOSFET 相較於 PMOSFET 具有面積小且速度快的優點。(4%)
   (c) 請在理想狀況下設計一個 MOS 電流鏡，以應用在直流偏壓電路中同時提供 I_0 和 $2I_0$，其中 I_0 為常數，並評估在實際製作時因通道長度調變效應(channel length modulation effect)所造成的影響。(6%)

3. (12%) 圖 1 顯示一個增強型 MOSFET 放大器，其中輸入信號 Vi 經由一個大電容耦合到閘極，汲極的輸出信號也經由另一大電容耦合到負載電阻 R_L。假設此電晶體的 $V_t = 1.5V$，$k_n'\left(\frac{W}{L}\right) = 0.25\ mA/V^2$，$V_A = 50V$，且耦合電容值夠大，在信號頻率下可視為短路，請分析此放大器並決定其小信號電壓增益(small-signal voltage gain)以及輸入電阻(input resistance)。

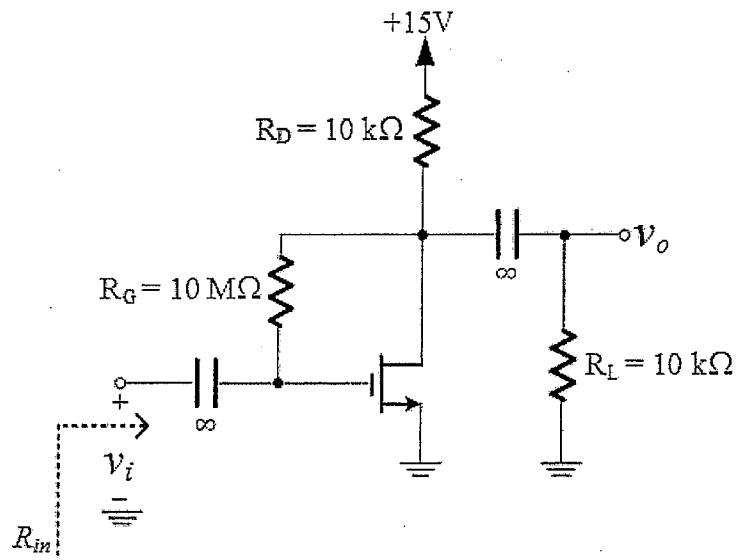


圖 1

背面有題

國立中山大學106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

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4. (20%) 請分析圖 2 的電路並求出所有節點的電壓和所有分路的電流，即 V_{B1}、I_{B1}、V_{C1}、I_{C1}、I_{E1}、V_{E2}、I_{E2}、I_{C2}、V_{C2}、I_{B2}。

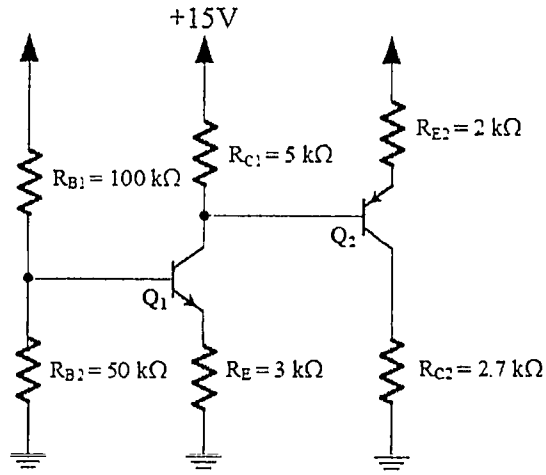

圖 2

5. (14%) 圖 3 為一常用的放大器電路，請分析此電路並計算 Vo 以及求出差動電壓增益。

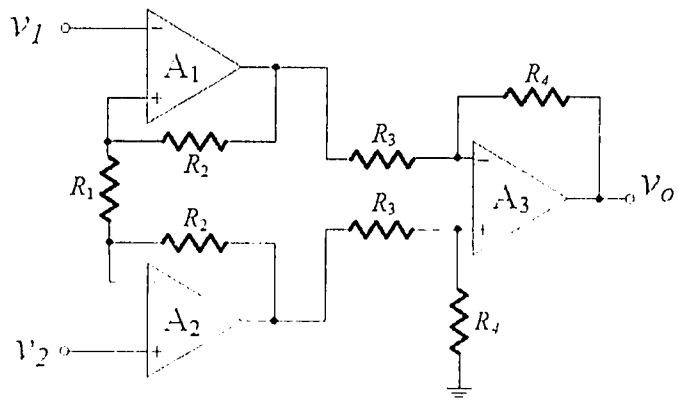

圖 3

6. (10%) 圖 4 為一電晶體放大器之電路圖，假設 β = 100，請求出它的電壓增益。

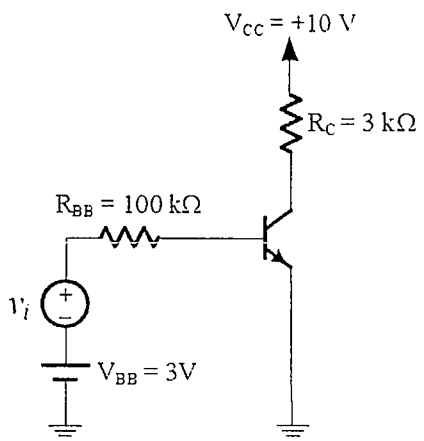

圖 4

國立中山大學106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）（選擇題）　　

I. For each question find one correct answer from five possible choices:

1. (2 points) The phenomenon of the emission, or ejection, of electrons from the surface of a metal in response to incident light is known as
   (a) photon-electron collision effect, (b) photon-induced-current effect, (c) photo-electric effect, (d) light-induced-conducting effect, (e) light-electric-coupling effect.

2. (3 points) The energy that can be obtained from complete annihilation (完全湮滅) of 1 g of mass is
   (a) 0, (b) 0.001 J, (c) 10^{10} J, (d) 3×10^{13} J, (e) 9×10^{13} J.

3. (3 points) If the energy produced from complete annihilation of 1 g of mass (c.f., question 1) is completely convert to photon, the wavelength of the light can be
   (a) 2.2×10^{-39} m, (b) 2.2×10^{-20} m, (c) 2.2×10^{-15} m,
   (d) 2.2×10^{-12} m, (e) 2.2×10^{-9} m.

4. (2 points) In his scattering experiment, Rutherford and his colleagues used a beam of α-particle that composes of
   (a) one electron, (b) one electron and one proton,
   (c) one proton and one neutron, (d) two protons and one neutron,
   (e) two protons and two neutrons.

5. (5 points) If a rod of length L_0 travels, in the sky, with a speed $u = 0.8c$ along its length, its length as observed by a man on the ground, will be
   (a) $0.4L_0$, (b) $0.6L_0$, (c) $0.8L_0$, (d) L_0, (e) $1.2L_0$.

6. (5 points) At 0 K, the Fermi energy of silver (Ag) is 5.54 eV. The Fermi temperature of silver is
   (a) 65000 K, (b) 5000 °C, (c) 0 K, (d) 100 °C, (e) 0 °C.

7. (5 points) The mean life-time of muons is 2.4×10^{-6} s when they decay at rest. When a beam of muons travels with a speed of $u = 0.8c$, their mean life-time as observed in the laboratory is found to be
   (a) 2.0×10^{-6} s, (b) 2.5×10^{-6} s, (c) 3.0×10^{-6} s, (d) 4.0×10^{-6} s, (e) 5.0×10^{-6} s.

8. (5 points) For hydrogen atom at very high energy level, i.e., the principle quantum number n is very large, the gap between the neighboring energy levels is proportional to
   (a) n^2, (b) n, (c) $\frac{1}{n}$, (d) $\frac{1}{n^2}$, (e) $\frac{1}{n^3}$.

9. (5 points) The ground state electron configuration of sodium (Na: Z = 11) is
   (a) 1s, (b) $1s^2 2s^2 2p^6 3s$, (c) $1s^2 2s^2 2p^6$, (d) $1s^2 2s^2 2p^6 3s^2$,
   (e) $1s^2 2s^2 2p^6 3s^2 3p$.

10. (5 points) Point out which one of following transitions is forbidden.
    (a) $2p \rightarrow 1s$, (b) $3s \rightarrow 2p$, (c) $2s \rightarrow 1s$, (d) $3p \rightarrow 1s$, (e) $3p \rightarrow 2s$.

背面有題

II When potassium, which has a work function $\phi = 2.0$ eV, is exposed to a beam of light of wavelength $\lambda = 400$ nm, the electrons are found to emit from the metal.

11. (5 points) The photons in the light beam have an energy
(a) 3.1 eV, (b) 4.0 eV, (c) 5.2 eV, (d) 6 eV, (e) 8 eV;

12. (5 points) The velocity of the electrons emitted can be
(a)400 nm/s, (b) 800 nm/s, (c) 5.5×10^5 m/s, (d) 6.22×10^5 m/s, (e) 8.0×10^5 m/s;

13. (10 points) The electrons have a wavelength
(a) 400 nm, (b) 800 nm, (c) 1.17 nm, (d) 0.5 nm, (e) 0.25 nm.

III. For the velocity distribution of gas molecules of mass m at temperature T is

$$N(u)du = 4\pi N\left(\frac{m}{2\pi kT}\right)^{3/2} \exp\left(-\frac{mu^2}{2kT}\right)u^2 du . \qquad (1)$$

Based on the distribution function solve following problems (14 and 15).

14. (10 points) The average speed of gas molecule $\langle u \rangle$ is

(a) $\left(\frac{kT}{\pi m}\right)^{1/2}$, (b) $\left(\frac{8kT}{3\pi m}\right)^{1/2}$, (c) $\left(\frac{8kT}{\pi m}\right)^{1/2}$, (d) $\left(\frac{4kT}{\pi m}\right)^{1/2}$, (e) $\left(\frac{2kT}{\pi m}\right)^{1/2}$,

15. (10 points) The equation (1) is known as Maxwellian distribution, in which the most probable speed of the gas molecules is $u_p = (2kT/m)^{1/2}$. For Maxwellian distribution, the root mean square of speed is written as $\langle u^2 \rangle^{1/2}$. So the relation of the three speeds is

(a) $\langle u^2 \rangle < u_p^{\,2} < \langle u \rangle^2$, (b) $\langle u^2 \rangle = u_p^{\,2} < \langle u \rangle^2$,

(c) $u_p^{\,2} < \langle u^2 \rangle < \langle u \rangle^2$, (d) $u_p^{\,2} < \langle u^2 \rangle = \langle u \rangle^2$,

(e) $u_p^{\,2} < \langle u \rangle^2 < \langle u^2 \rangle$.

IV · A particle at ground state is described by the wave function

$$\psi(p) = \frac{\sqrt{8}}{\pi}\left(\frac{\hbar}{a_0}\right)^{\frac{5}{2}} \Bigg/ \left[p^2 + \left(\frac{\hbar}{a_0}\right)^2\right]^2$$, where $\hbar$ is Plank constant, p is the momentum of the particle and a_0 is a constant.

16. (5 points) The momentum distribution $f(\vec{p})d\vec{p}$ can be given by

(a) $-\frac{\sqrt{8}}{\pi}\frac{\left(\frac{\hbar}{a_0}\right)^{\frac{5}{2}}}{\left[p^2 + \left(\frac{\hbar}{a_0}\right)^2\right]^2}dp$, (b) $\frac{\sqrt{8}}{\pi}\frac{\left(\frac{\hbar}{a_0}\right)^{\frac{5}{2}}}{\left[p^2 + \left(\frac{\hbar}{a_0}\right)^2\right]^2}dp$

(c) $\frac{8}{\pi}\frac{\left(\frac{\hbar}{a_0}\right)^5}{\left[p^2+\left(\frac{\hbar}{a_0}\right)^2\right]^4}pdp$, (d) $\frac{8}{\pi^2}\frac{\left(\frac{\hbar}{a_0}\right)^5}{\left[p^2+\left(\frac{\hbar}{a_0}\right)^2\right]^4}(4\pi)p^2dp$,

(e) $\frac{\left(\frac{\hbar}{a_0}\right)^5}{\left[p^2+\left(\frac{\hbar}{a_0}\right)^2\right]^4}4\pi p^2dp$.

17. (5 points) The most probable magnitude of the momentum of the particle is

(a) $\frac{\hbar}{a_0}$, (b) $\frac{\hbar}{\sqrt{3}\,a_0}$, (c) $\frac{\hbar}{\sqrt{2}\,a_0}$, (d) $\frac{\hbar}{3a_0}$, (e) $\frac{\hbar}{2a_0}$.

18. (10 points) The expectation value of momentum $\langle p\rangle$ is

(a) $\frac{8\hbar}{\pi\ a_0}$, (b) $\frac{4\hbar}{\pi\ a_0}$, (c) $\frac{8\hbar}{3\pi\ a_0}$, (d) $\frac{2\hbar}{\pi\ a_0}$, (e) $\frac{8\hbar}{5\pi\ a_0}$.

Constant and special functions

Plank's constant: $h = 6.63 \times 10^{-34}$ J·s
Mass of electron: $m_e = 9.109 \times 10^{-31}$ kg
$1J = 6.2415 \times 10^{18}$ eV
Boltzmann constant: $k = 1.38 \times 10^{-23}$ J K^{-1}
Avogaderlor constant: $N_a = 6.022 \times 10^{23}$ mol^{-1}
Ground energy of hydrogen : -13.6 eV
Charge of electron: 1.602×10^{-19} C
Speed of light: $c = 3.0 \times 10^8$ m s^{-1}

Values of the integral $I_n = \int_0^\infty x^n e^{-ax^2}dx$

n	I_n
0	$\frac{1}{2}\pi^{1/2}a^{-1/2}$
1	$\frac{1}{2}a^{-1}$
2	$\frac{1}{4}\pi^{1/2}a^{-3/2}$
3	$\frac{1}{2}a^{-2}$
4	$\frac{3}{8}\pi^{1/2}a^{-5/2}$