國立雲林科技大學 103 學年度 系所：電子系
碩士班招生考試試題 科目：工程數學(3)

1. Perform the indicated operation, give that (15 分)

$$A=\begin{bmatrix}1 & 2 & -1\\ 3 & -2 & 2\end{bmatrix} \quad B=\begin{bmatrix}1 & -2 & 0\\ 0 & 2 & 3\end{bmatrix} \quad C=\begin{bmatrix}2 & -1\\ 3 & 4\\ 1 & 0\end{bmatrix}$$

(a)(A+B)C (b) $(BC)^T$ (c) If $3X+2(A-B)=0$, Find X

2. Give a 3x3 matrix $A=\begin{bmatrix}1 & 2 & 3\\ 0 & 1 & 1\\ 1 & 4 & 6\end{bmatrix}$, and $B=\begin{bmatrix}1\\ 1\\ 1\end{bmatrix}$ (15 分)

(a) Find the row-echelon form of the augmented matrix [A | B]

(b) What is the rank of [A | B] (c) Find the solution of Ax=B

3. Find the eigenvalues and eigenvectors of A. $A=\begin{bmatrix}-2 & 2 & -3\\ 2 & 1 & -6\\ -1 & -2 & 0\end{bmatrix}$ (10 分)

4. If $\vec{A}=3\vec{i}-\vec{j}-2\vec{k}$, $\vec{B}=\vec{i}+2\vec{j}-3\vec{k}$, Find (a) $\vec{A}\bullet\vec{B}$ (b) $\vec{A}\times\vec{B}$ (c)Angle between $\vec{A}$ *and* $\vec{B}$ (d) The projection of $\vec{A}$ on $\vec{B}$ (10 分)

5. Assume that the uniform ice ball has a volume 1000cm^3, its melting rate is proportional to its surface area. After one minute, the volume of the ice ball decreased to be 729cm^3. How long will it takes that the volume is 125cm^3? (15 分)

6. Choose a constant α so that the differential equation is exact, then produce a potential function and obtain the general solution. (15 分)

$$2xy^3-3y-(3x+\alpha x^2y^2-2\alpha y)y'=0$$

7. Find the general solution of the differential equation

$$x^2y''+3xy'+y=9x^2+8x+5.$$ (10 分)

8. If Laplace Transform is defined as $F(s)=\mathcal{L}(f(t))=\int_0^\infty f(t)\cdot e^{-st}dt$, please find $\mathcal{L}(t^2)$. (10 分)

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科目：電子學(2)

本試題共八題，每題得分如各題中所示，共計 100 分，請依題號作答並將答案寫在答案卷上，違者不予計分。

1. (5 分) Draw the voltage transfer characteristic (VTC) for quantifying the operation of the inverter, and mark the six parameters of the VTC (V_{OH}, V_{OL}, V_{IH}, V_{IL}, noise margin NM_H and NM_L).

2. Fig. P2 shows a circuit that provides an output voltage v_o whose value can be varied by turning the wiper of the 50-KΩ potentiometer.
   (1) (4 分) Find the voltage v_o when potentiometer is set to the bottom.
   (2) (4 分) Find the voltage v_o when potentiometer is set to the top.
   (3) (2 分) Find the change in v_o corresponding to each turn of a 10 turn 50-KΩ potentiometer.

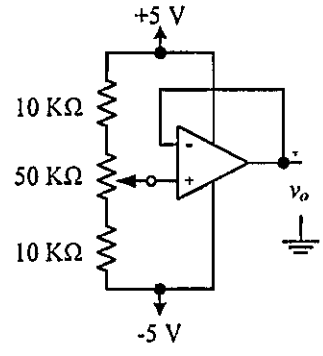

Fig. P2

3. Using the constant voltage drop (V_D = 0.7V) diode model
   (1) (5 分) find the v_o and i_o for the circuits shown in Fig P3-1.
   (2) (5 分) find the v_o and i_o for the circuits shown in Fig P3-2.

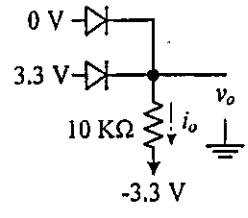

Fig. P3-1

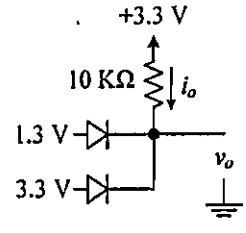

Fig. 3-2

4. An NMOS operates in the triode region, with small v_{DS} and with the gate-source voltage in range 0V to 3.3V. (channel length = 1μm, $k_n = \mu_n \bullet Cox$ = 100μA/V^2, V_t = 0.5V)
   (1) (5 分) Show the i_D equation in the triode region.
   (2) (5 分) What channel width of this NMOS is needed to ensure that the available resistance is around 2KΩ when operated in triode region?

5. For a general purpose PNP BJT
   (1) (5 分) Draw the hybrid-π small-signal model with parameters: v_π, r_π , $g_m v_\pi$, r_o.
   (2) (5 分) Draw the T small-signal model with parameters: $g_m v_\pi$, v_π, r_e , r_o.
   (3) (5 分) Show the definition of model parameters in terms of DC bias current: g_m= ?, r_e= ?, r_π=? and r_o=?.

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6. The voltage gain of the amplifier shown in Fig. P6 is $-80V/V$ when $I=100\mu A$.
If I is decreased down to $25\mu A$,
(1) (10 分) what will be the voltage gain?
(2) (10 分) what will be the transconductance of the MOS transistor (with respect to that with $I=100\mu A$)?
The transistor operates in the saturation region in both cases.

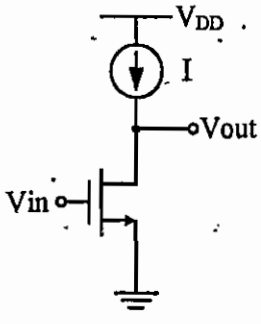


Fig. P6

7. For the amplifier shown in Fig. P7, please calculate
(1) (10 分) small-signal differential voltage gain.
(2) (10 分) input common-mode voltage range.
$|V_{tp}|=0.8V$ and $\mu_p C_{ox}\frac{W}{L}=3.5\times10^{-3}\,A/V^2$ and $\lambda=0$.

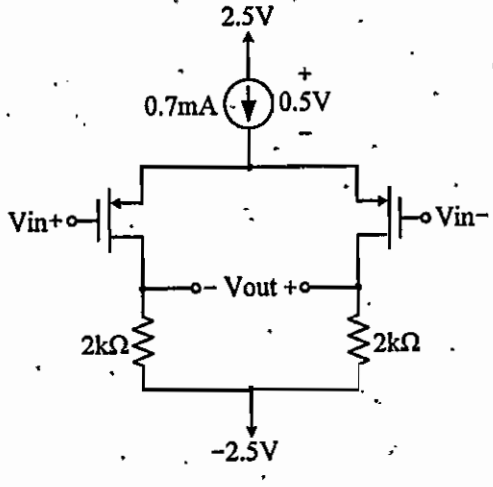
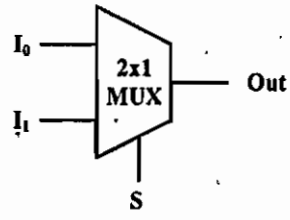


Fig. P7

8. (10 分) Briefly explain the body effect of MOS transistor.

1. (10 pts) Convert the following hexadecimal representations of 2's complement binary numbers to decimal number.
   (a) xF0
   (b) x7FF
   (c) x16
   (d) x8000
   (e) x1

2. (10 pts) A symbol of 2-to-1 mux is listed below. Please draw the gate-level circuit of 2-to-1 mux.



3. (10 pts) Implement a 4-to-1 mux using only 2-to-1 muxes making sure to be properly connected all of the terminals. Remember that you will have 4 inputs, 2 control signals, and 1 output. Write out the truth table for this circuit.

4. (10 pts) Given the following truth table, generate the gate-level logic circuit, using the Programmable Logic Array (PLA). Remember that this circuit have 3 inputs and 2 outputs.

A	B	C	F_0	F_1
0	0	0	1	1
0	0	1	0	1
0	1	0	0	0
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	1
1	1	1	0	0

5. (10 pts) Please answer the following questions..
   (a) What is called 3C's misses for cache memory design?
   (b) How to reduce them? Explain your design techniques as many as you can.

6. (10 pts) Suppose we have a 32-bit MIPS word containing the value 0x008A1021. We would like to know what MIPS machine instruction this represents.
   (a) Write this instruction word in binary. Draw boxes around the bits that make up the different fields of the instruction and then label the instruction fields (opcode, rs, etc.).
   (b) What is the format of this instruction? R, I, or J?
   (c) Translate this instruction to assembly language. Use symbolic register names like $t8 instead of absolute register numbers like $24.

7. (10 pts) In a processor implementation, a data hazard can slow down the pipeline. What is a data hazard? Give a short example using MIPS code that illustrates the problem and give a brief explanation of what the problem is.

8. (10 pts) (a) Give three advantages of programming in a higher level language (like C) over programming in assembler (like MIPS). (b) Give two reasons why registers are used as the source and destination operands for arithmetic instructions in the MIPS.

9. (10 pts) Give the six steps in the execution of a procedure in MIPS.

10. (10 pts) One of the terms we encountered in discussing memory hierarchies and caches was spatial locality. Give a brief explanation of what this term means and a short example that gives one illustration of this property.

$q=1.6\times10^{-19}C$, $kT=0.025eV$, $\varepsilon_{Si}=12\times8.85\times10^{-14}F/cm$, $n_i=10^{10}cm^{-3}$, $\ln(10)=2.3$

1. Describe the crystal structure of the single-crystalline silicon. **(20%)**

2. Describe the energy band gap differences in the metal, semiconductor, and insulator materials. **(15%)**

3. Describe briefly the formation of the depletion region in a p-n junction diode. **(15%)**

4. Explain (a) Fermi-Dirac Distribution Function **(5%)**
(b) Diffusion Capacitance **(5%)**
(c) One-Sided Abrupt Junction **(5%)**

5. Describe the content of breakdown mechanisms for p^+n^+ and pn junctions, respectively. **(15%)**

6. A silicon PIN junction has the doping profile shown in the **Figure 1**. The "I" corresponds to an ideal intrinsic region in which there is no impurity doping concentration. A reverse-bias voltage is applied to the PIN junction so that the total depletion width extends from −1.5μm to +1.5 μm. (a) Calculate the magnitude of the electric field at x=0, (b) Sketch the electric field through the PIN junction and (c) Calculate the reverse bias that must be applied. **(20%)**

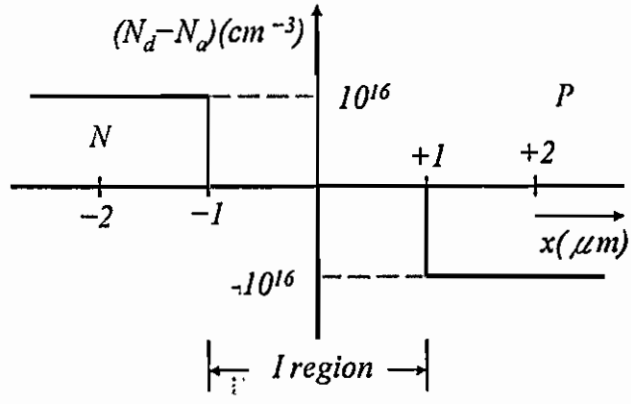


Figure 1

Useful Physical Constants: $\varepsilon_0 \approx \frac{10^{-9}}{36\pi}$ (F/m); $\mu_0 = 4\pi \times 10^{-7}$ (H/m)

1. A voltage of 1.00 V is dropped across a resistor that has 5.00 μA passing through it.
   (a) How much power is dissipated in the resistor? (10%)
   (b) If the resistor is made of a 1.00-mm-diameter, 1.00-m-long alloy, find out the resistivity of the alloy. (10%)
2. A plane defined by $3x + 2y + z = 6$ separate two dielectrics. The first dielectric, on the side of the plane containing the origin, has $\varepsilon_{r1} = 3.0$ and $\mathbf{E}_1 = 4.0\,\mathbf{a}_z$ V/m. The other dielectric has $\varepsilon_{r2} = 6.0$. Find $\mathbf{E}_2$. (10%)
3. The x-z plane separates magnetic material with $\mu_{r1} = 2.0$ (for y < 0) from magnetic material with $\mu_{r2} = 4.0$ (for y > 0). In medium 1, there is a field $\mathbf{H}_1 = 2.0\mathbf{a}_x + 4.0\mathbf{a}_y + 6.0\mathbf{a}_z$ A/m. Find $\mathbf{H}_2$ assuming the boundary has a surface current
   (a) $\mathbf{K} = 0$; (10%)
   (b) $\mathbf{K} = 2.0\mathbf{a}_x - 2.0\mathbf{a}_z$ A/m. (10%)
4. Convert the following instantaneous quantities to phasors:
   (a) $A = 16\cos(2\pi \times 10^6\, t + \pi/4)$ (10%)
   (b) $\mathbf{A}(x, t) = 10\sin(2\pi \times 10^8\, t + 2x)\,\mathbf{a}_y$ (10%)
5. A wave propagates in a nonmagnetic conductor. If the electric field vector is $\mathbf{E}(z, t) = 10\, e^{-480000z}\cos(2\pi \times 10^9 t - \beta z)\,\mathbf{a}_x$ mV/m.
   (a) What is the approximated value of β? (10%)
   (b) What is the approximated value of skin depth? (10%)
6. Suppose a 20-Ω transmission line is terminated in an 80-Ω load. Determine the required impedance of a quarter-wave matching section of transmission line. (10%)

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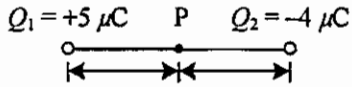
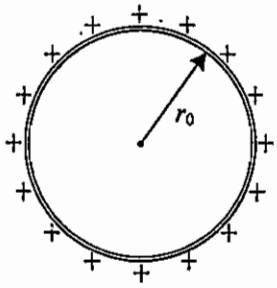
1. 圖一畫出相距 2 m 的二個帶電粒子，假設比例係數 $k = 1/4\pi\varepsilon_0 = 9.0 \times 10^9\ \text{N}\cdot\text{m}^2/\text{C}^2$。
   (a) 粒子 Q_1 所受靜電力的大小與方向為何？(5%)
   (b) 在二個粒子中間之處（位置 P），電場的大小與方向為何？(5%)



圖一

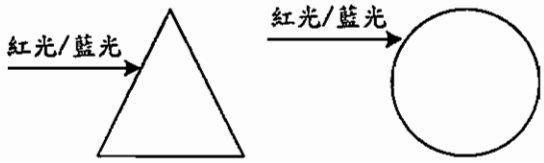
2. 考慮圖二，在一個半徑為 r_0 的薄球殼上有電荷均勻分布，而且總電荷為 Q。根據下列條件，計算在距離球心 r 處的電場大小。
   (a) r 落在球殼外（$r > r_0$）。(5%)
   (b) r 落在球殼內（$r < r_0$）。(5%)



圖二

3. 假設有一個電容，電容值為 200 μF，電壓為 50 V。
   (a) 此電容儲存之電能有多少？(5%)
   (b) 假如此電容儲存之能量在 1.0 ms 內完全被釋放，則輸出功率為何？(5%)

4. (a) 說明斯奈爾定律(Snell's law)。(4%)
   (b) 如圖四(a)所示，假設紅光與藍光以相同角度從空氣入射一個石英作成的稜鏡，且在石英中藍光的折射率大於紅光($n_{blue} > n_{red}$)。畫出藍光與紅光的行進軌跡。(3%)
   (c) 如圖四(b)所示，紅光與藍光以相同角度從空氣入射一個石英球。畫出藍光與紅光的行進軌跡。(3%)

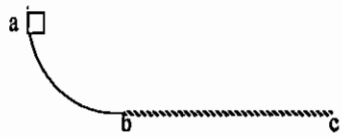


圖四(a)　圖四(b)

5. 說明楊氏雙狹縫實驗(Young's double-slit experiment)，包括實驗架構、實驗結果，以及這個實驗的重要性。(10%)

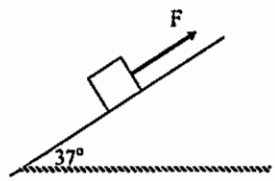
6. 若忽略空氣阻力，自高出地面 24.5m 之窗口，以初速度 39.2m/s 仰角 30^0 拋出一球，試估算：(a) 拋出後幾秒鐘，球恰著地？(b) 著地時，球之水平位移若干？(8%)

7. 如圖五質量 20kg 之小物體自 a 點自由下滑，ab 為半徑 10m 之 1/4 圓弧，物體達 b 點時速率為 10m/s，滑行至 c 點而停止，bc=25m，試求（a）bc 水平軌道上之動摩擦係數？（b）由 a 滑至 b，摩擦力對物體消耗若干能量？(8%)



圖五

8. 如圖六質量 10kg 之木塊置於斜角 37° 之(a)光滑斜面上，今欲使此物體以 $2m/s^2$ 沿斜面向上作等加速度運動，試求需沿斜面向上施力若干？(b)若木塊與斜面間之靜摩擦係數為 0.4；而動摩擦係數為 0.3，則需沿斜面方向施力 F 為何，木塊才能以 $2m/s^2$ 沿斜面向上作等加速度運動？(8%)

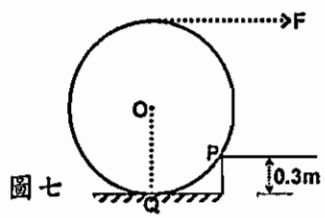


圖六

9. 有一直徑 1m、重 50kg 磨石，轉速 900 轉/分，今有一工具以 200 牛頓之力正壓於此磨石邊緣，則此磨石在 10 秒後停止轉動，試求此工具與磨石間之摩擦係數？(5%)

10. 在一個標準滾輪溜冰場上，質量 75 kg 的父親與質量 25 kg 之小女兒面對面的站立，父親推動女兒使之以 0.6m/s 之速率後退，試求父親之運動速率及運動方向。(5%)

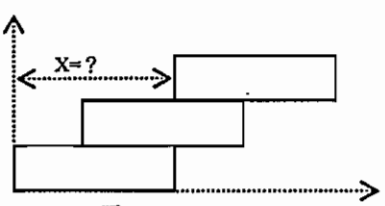
11. 一圓柱體受重力 500 牛頓、半徑 0.8m，如欲通過高 0.3m 之障礙物，至少需如圖七水平施力 F 為何？ (5%)



圖七

12. 均勻細棒長 ℓ 公尺，質量 m 公斤，以質心上端距質心距離 d 公尺處之點為轉軸構成複擺、求複擺週期。(6%)

13.如圖八以 3 個長度 ℓ 公尺、質量 m 公斤之完全相同磚塊堆積，試求磚塊不落下時、x 的最大值。(5%)



圖八