

國立中山大學 112 學年度

碩士班暨碩士在職專班招生考試試題

科目名稱：半導體概論【電機系碩士班甲組】

— 作答注意事項 —

考試時間：100 分鐘

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國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：半導體概論【電機系碩士班甲組】

題號：431012

※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

Dielectric constant of Si = 11.7 ; SiO₂ = 3.9.

1. An *n*-channel MOSFET with $W = 6 \mu\text{m}$, $L = 1.5 \mu\text{m}$, and $t_{ox} = 80 \text{ \AA}$. When the transistor is biased in the saturation region, the drain current is $I_D = 0.132 \text{ mA}$ at $V_{GS} = 1.0 \text{ V}$ and $I_D = 0.295 \text{ mA}$ at $V_{GS} = 1.25 \text{ V}$. Determine the electron mobility and the threshold voltage. (20%)
2. An *n*-channel MOSFET with a substrate doping concentration of $N_A = 2 \times 10^{16} \text{ cm}^{-3}$, a threshold voltage of $V_T = 0.4 \text{ V}$, and a channel length of $L = 1 \mu\text{m}$. The device is biased at $V_{GS} = 1 \text{ V}$ and $V_{DS} = 2.5 \text{ V}$. Determine the ratio of actual drain current compared to the ideal value. (20%)
3. A Si *p-n* junction at $T = 300 \text{ K}$ with diffusion coefficients $D_n = 25 \text{ cm}^2/\text{s}$, $D_p = 10 \text{ cm}^2/\text{s}$, doping concentrations $N_A = N_D = 10^{16} \text{ cm}^{-3}$, and excess minority carrier lifetimes $\tau_0 = \tau_{n0} = \tau_{p0} = 5 \times 10^{-7} \text{ s}$. Assume the diode is reverse biased at $V_R = 5 \text{ V}$. Determine the relative magnitudes of the ideal reverse-saturation current density and the generation current density. (20%)
4. The metallurgical base width of a Si *npn* bipolar transistor is $0.80 \mu\text{m}$. The base and collector doping concentrations are $N_B = 5 \times 10^{16} \text{ cm}^{-3}$ and $N_C = 2 \times 10^{15} \text{ cm}^{-3}$. Determine the punch-through voltage. (20%)
5. A Si PIN diode with an intrinsic region width of $W = 20 \mu\text{m}$. Assume that the photon flux is $10^{17} \text{ cm}^{-2}\text{-s}^{-1}$ and the absorption coefficient is $\alpha = 10^3 \text{ cm}^{-1}$. Calculate the photocurrent density. (20%)

國立中山大學 112 學年度 碩士班暨碩士在職專班招生考試試題

科目名稱：電子學(甲組)【電機系碩士班甲組】

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國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電子學(甲組)【電機系碩士班甲組】

題號：431009

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1. (20%)
 - (a) Please draw I-V plots of bipolar junction transistors (BJTs) with and without Early effect (5%).
 - (b) How does the “Early effect” affect the small-signal voltage gain? Please explain by drawing and using the small-signal model (5%).
 - (c) Please explain why the gate current is zero for the ideal metal-oxide-semiconductor field-effect transistor (MOSFET) (5%).
 - (d) What is the depletion-type MOSFET? Please explain by drawing and using the I-V curve (5%).
2. (10%) The circuit shown in Fig. 1 uses an op amp having a ± 5 -mV offset.
 - (a) What does the output offset become with the input ac coupled through a capacitor C (5%)?
 - (b) If, instead, a large capacitor is placed in series with the 1-k Ω resistor (R_A), what does the output offset become (5%)?
3. (15%) A full-wave bridge-rectifier circuit with a 1-k Ω load operates from a 120-V (rms) 60-Hz household supply through a 12-to-1 step-down transformer having a single secondary winding. It uses four diodes, each of which can be modeled to have a 0.7-V drop for any current.
 - (a) What is the peak value of the rectified voltage across the load (5%)?
 - (b) For what fraction of a cycle does each diode conduct (5%)?
 - (c) What is the output frequency? Please explain the reason by drawing the waveform at input and output terminals (5%).
4. (20%) Consider the circuit of Fig. 2 for the case: $I = 400 \mu\text{A}$ and $V_{OV} = 0.4 \text{ V}$, $R_{sig} = 200 \text{ k}\Omega$, $R_D = 40 \text{ k}\Omega$, $C_{gs} = 4 \text{ pF}$, and $C_{gd} = 0.5 \text{ pF}$. Find
 - (a) the overall gain v_o/v_{sig} at midband frequency (5%),
 - (b) the high-frequency poles (10%),
 - (c) an estimate of f_H (5%).
5. (20%) The amplifier shown in Fig. 3 has $V_{CC} = 2 \text{ V}$, $R_{sig} = R_L = 2 \text{ k}\Omega$, $R_C = 2 \text{ k}\Omega$, $R_B = 100 \text{ k}\Omega$, $\beta = 100$, $C_\mu = 1 \text{ pF}$, and $f_T = 500 \text{ MHz}$. Assume the coupling capacitors to be very large. Thermal voltage is 0.025 V.
 - (a) Find the dc collector current of the transistor (5%).
 - (b) Find the overall gain v_o/v_{sig} at midband frequency (5%).
 - (c) Find f_H (10%).
6. (15%) Considering the N-MOSFET inverter circuit is shown in Fig. 4. The Q1 has the following parameters $k_1=(W/L)\mu_n C_{ox}=20 \mu\text{A}/\text{V}^2$ and $V_{T1}= -2 \text{ V}$ and Q2 has the following parameters $k_2=(W/L)\mu_n C_{ox}=200 \mu\text{A}/\text{V}^2$ and $V_{T2}=1 \text{ V}$. V_{DD} is set to be 5 V.
 - (a) Please find the logic swing of the inverter circuit (5%).
 - (b) Please find the noise margins of the inverter circuit (5%).
 - (c) Please find the average static power dissipation of the inverter circuit (5%).

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電子學(甲組)【電機系碩士班甲組】

題號：431009

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共 2 頁第 2 頁

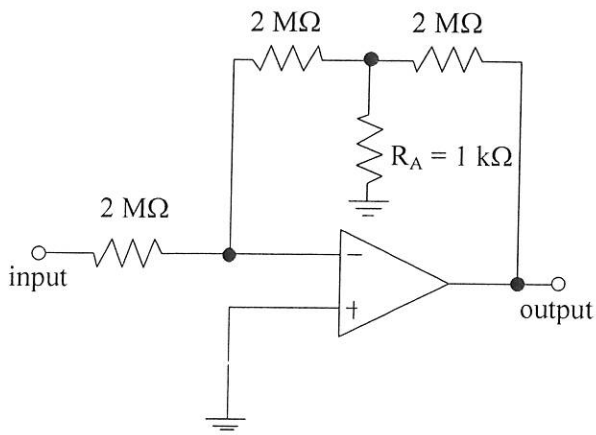


Fig. 1

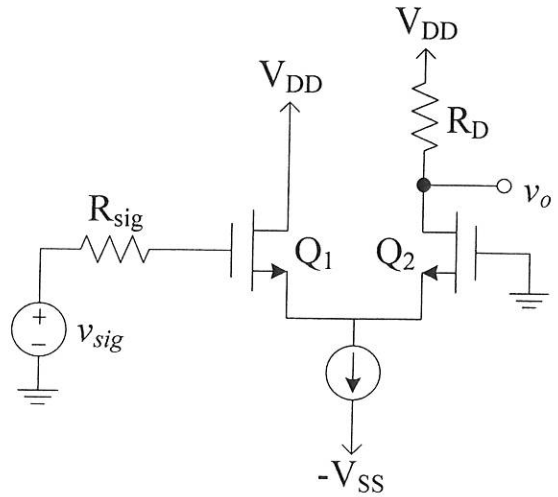


Fig. 2

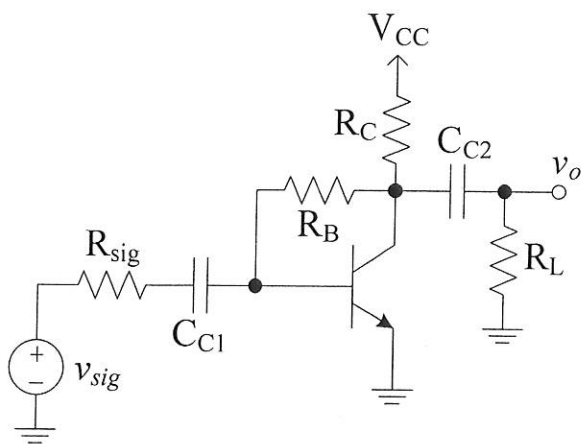


Fig. 3

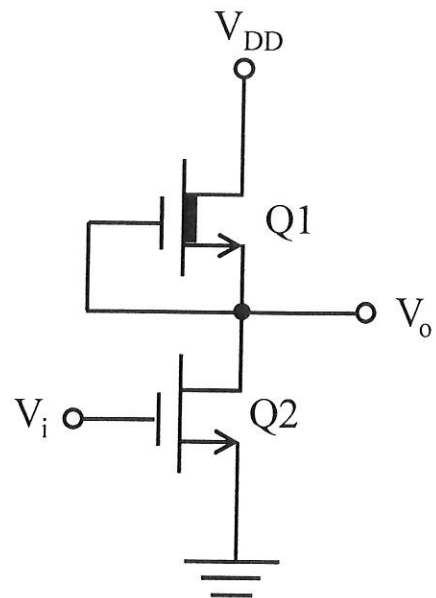


Fig. 4

國立中山大學 112 學年度 碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學乙【電機系碩士班乙組】

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國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學乙【電機系碩士班乙組】

題號：431001

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共 4 頁第 1 頁

下面 1-20 題為複選題，每題 5 分，總分 100 分，每題有 5 個選項，其中至少有 1 個是正確答案。答錯 1 個選項者，得 3 分，答錯 2 個選項者，得 1 分，答錯多於 2 個選項或未作答者，該題以零分計算。

1. Consider the differential equation (DE) below. Which of the following is correct?

$$\frac{dy}{dx} - (y - 1)(1 - 2y) = 0$$

- (A) This is a linear first-order ordinary DE.
(B) This is an autonomous DE.
(C) One of the critical points is semi-stable.
(D) None of the critical points is semi-stable.
(E) The solution $y(x)$ increases with x when x is defined on $(1/2, \infty)$.
2. Identify the correct statement(s) for the differential equation (DE), $(2t^2 - u^2)dt = (2tu)du$.
(A) It is a linear homogeneous DE.
(B) It's a second-order DE.
(C) It is a Bernoulli's equation.
(D) It is an exact equation.
(E) There exists a singular point.
3. Following question 2, given that the solution has the form of $u(t) = A \frac{\sqrt{Bt^2 + Ct^D}}{E}$, which of the following is correct?
(A) $A = 1, B = 2, C = \text{any constant}, D = 1, \text{ and } E = 9$.
(B) $A = 1, B = 6, C = \text{any constant}, D = -1, \text{ and } E = 3$.
(C) $A = -1, B = 2, C = \text{any constant}, D = -1, \text{ and } E = 9$.
(D) $A = -1, B = 6, C = \text{any constant}, D = -1, \text{ and } E = 3$.
(E) The interval of definition of the general solution is $(-\infty, \infty)$.
4. Consider the differential equation $dy = (ay^2 + by + c)dx$. If $a = c = 1$ and $b = -2$, which statement(s) below is/are correct?
(A) None of the critical points is a repeller.
(B) The general solution is $y = 1 - \frac{1}{x+c}$.
(C) The general solution is $y = 1 + \frac{1}{x-c}$.
(D) The solution is divergent for any given initial conditions.
(E) The solution is convergent for any given initial conditions.
5. Following question 4, given $a = 1, b = 0, \text{ and } c = 4$, identify the correct statement(s).
(A) There exist constant solutions.
(B) There exist relative extrema.
(C) There is a single critical point.
(D) The solution is defined on the interval of $(-\infty, \infty)$.
(E) Any solution must be increasing on the interval on which it is defined.

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科目名稱：工程數學乙【電機系碩士班乙組】

題號：431001

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共 4 頁第 2 頁

6. Consider the differential equation $x^2y'' - 4xy' + 6y = 0$. Identify the INCORRECT statement(s).
- (A) $y_1 = x^3$ and $y_2 = |x|^3$ are two linear independent solutions.
 - (B) The general solution is defined on the interval of $(-\infty, \infty)$.
 - (C) Given the initial conditions $y(0) = 0$ and $y'(0) = 0$, the initial value problem (IVP) has a unique solution.
 - (D) Given the initial conditions $y(1) = 3$, $y'(1) = 1$, the IVP has a unique solution.
 - (E) The general solution is $y = c_1x^2 + c_2x^3$.
7. Which of the following is/are true about the differential equation, $\ddot{y} - 2\dot{y} + y - 4x^2 + 3 - \frac{e^x}{x} = 0$?
- (A) It is a homogeneous differential equation.
 - (B) The associated homogeneous equation is $c_1x + c_2x \ln x$.
 - (C) The complementary function $y_c = c_1e^x + c_2xe^x$.
 - (D) The particular solution $y_p = 4x^2 + 16x + 21 - xe^x + xe^x \ln x$.
 - (E) The interval of definition of the general solution is $(-\infty, \infty)$.
8. Which of the following is/are NOT true about the differential equation (DE), $\left(\frac{d^2y}{dx^2}\right)^2 = y^2$?
- (A) Both e^{ix} and e^{-ix} are solutions of DE.
 - (B) Both $\cos x$ and e^x are solutions of DE.
 - (C) The linear combination of $c_1 \cos x + c_2 \sin x$ is the solution of DE.
 - (D) The linear combination of $c_1e^x + c_2e^{-x}$ is the solution of DE.
 - (E) The linear combination of $c_1e^x + c_2e^{-x} + c_3 \cos x + c_4 \sin x$ is the solution of DE.
9. Given the initial value problem of $t^2y'' - 5ty' + 8y = 8t^6$ with $y\left(\frac{1}{2}\right) = 0$ and $y'\left(\frac{1}{2}\right) = 0$, identify the correct statement(s).
- (A) If the particular solution is in the form of At^B , $A + B = 7$.
 - (B) If the complementary function is in the form of $c_1f_1(t) + c_2f_2(t)$, $c_1 + c_2 = -7$.
 - (C) When $t \rightarrow -\infty$, $y \rightarrow -\infty$.
 - (D) There exist relative extrema.
 - (E) The interval of definition of the general solution is $(-\infty, \infty)$.
10. Consider the given functions, identify the INCORRECT statement.
- (A) Given $\sec x$ is analytic at $x = 0$, the interval of convergence is $(-\infty, \infty)$.
 - (B) Given the differential equation (DE) of $\ddot{y} + \ln(t+1)\dot{y} + y = 0$ is analytic at $t = 0$, the interval of convergence is $[-1, 1]$.
 - (C) $t = 0$ is a singular point of the DE, $t\ddot{y} + (\sin t)y = 0$.
 - (D) $x = 0$ is a singular point of the DE, $\ddot{y} + 5x\dot{y} = -\sqrt{xy}$.
 - (E) Given the DE of $x\ddot{y} + \dot{y} = -10y$, the method of Frobenius can only yield a single solution.

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共 4 頁第 3 頁

11. Consider the linear system $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3] \in \mathbb{R}^{5 \times 3}$, $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are column vectors of \mathbf{A} , and \mathbf{b} is a non-zero vector. Suppose $\mathbf{b} = \mathbf{a}_1 + \mathbf{a}_2 = 2\mathbf{a}_2 + \mathbf{a}_3$. Which of the following statements are true?
- (A) The linear system has exactly two solutions.
 (B) The linear system has at most two solutions.
 (C) $\text{rank}([\mathbf{A}, \mathbf{b}]) = \text{rank}(\mathbf{A}) \leq 2$.
 (D) $\mathbf{x} = [1, 3, 1]^T$ is a solution of the linear system.
 (E) The vectors $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are linearly dependent.
12. Consider the linear system $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3] \in \mathbb{R}^{3 \times 3}$, $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are column vectors of \mathbf{A} , and \mathbf{b} is a non-zero vector. Suppose
- $$\mathbf{a}_1 - \mathbf{a}_2 + 3\mathbf{a}_3 = \mathbf{0}, \quad \mathbf{a}_1 + 2\mathbf{a}_2 - \mathbf{a}_3 = \mathbf{b}, \quad \text{rank}(\mathbf{A}) = 2.$$
- Which of the following are solutions of the linear system?
- (A) $\mathbf{x} = [-1, 4, -7]^T$
 (B) $\mathbf{x} = [3, 0, 5]^T$
 (C) $\mathbf{x} = [2, 4, -2]^T$
 (D) $\mathbf{x} = [3, 1, 3]^T$
 (E) $\mathbf{x} = [-2, 2, -6]^T$
13. Two matrices are row equivalent if one can be changed to the other by a sequence of elementary row operations. Which of the following statements are true?
- (A) If there exists a matrix \mathbf{R} such that $\mathbf{B} = \mathbf{RA}$, then \mathbf{A} and \mathbf{B} are row equivalent.
 (B) If two matrices are row equivalent, then they have the same null space.
 (C) If two matrices are row equivalent, then they have the same eigenvalues.
 (D) If \mathbf{E} is the reduced row echelon form of \mathbf{A} , then \mathbf{E} and \mathbf{A} are row equivalent.
 (E) Let $\mathbf{A} \in \mathbb{R}^{m \times n}$, $\mathbf{C} \in \mathbb{R}^{m \times n}$, and $\mathbf{b} \in \mathbb{R}^m$ be given. If \mathbf{A} and \mathbf{C} are row equivalent, then the two linear systems $\mathbf{Ax} = \mathbf{b}$ and $\mathbf{Cx} = \mathbf{b}$ have the same solution set.
14. Consider the linear system $\mathbf{Ax} = \mathbf{b}$. Let $\mathbf{A} = \mathbf{QR}$, where \mathbf{Q} is an orthogonal matrix, and \mathbf{R} is an upper triangular matrix. Suppose
- $$\mathbf{R} = \begin{bmatrix} -1 & 4 & 2 \\ 0 & -2 & 1 \\ 0 & 0 & 3 \end{bmatrix}, \quad \mathbf{Q}^T \mathbf{b} = \begin{bmatrix} -3 \\ 7 \\ 15 \end{bmatrix}, \quad \mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$
- Which of the following statements are true?
- (A) $x_1 = 9$ (B) $x_2 = 1$ (C) $x_3 = 5$ (D) $x_1 + x_2 + x_3 = 12$ (E) $x_1 + x_2 + x_3 = 14$
15. Let $\hat{\mathbf{x}}$ be a least-squares solution of the linear system $\mathbf{Ax} = \mathbf{b}$. Which of the following statements are true?
- (A) $\hat{\mathbf{x}}$ satisfies $\mathbf{A}\hat{\mathbf{x}} = \mathbf{b}$.
 (B) $\hat{\mathbf{x}}$ satisfies $\mathbf{A}^T \mathbf{A}\hat{\mathbf{x}} = \mathbf{A}^T \mathbf{b}$.
 (C) $\hat{\mathbf{x}}$ always exists.
 (D) $\hat{\mathbf{x}}$ is unique.
 (E) $\mathbf{b} - \mathbf{A}\hat{\mathbf{x}}$ is orthogonal to any vector in the range space of \mathbf{A} .

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學乙【電機系碩士班乙組】

題號：431001

※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 4 頁 第 4 頁

16. Let \mathbf{x}_1 and \mathbf{x}_2 be eigenvectors of \mathbf{A} , and λ_1 and λ_2 be the corresponding eigenvalues. Suppose

$$\mathbf{x}_1 = \begin{bmatrix} -1 \\ 2 \end{bmatrix}, \mathbf{x}_2 = \begin{bmatrix} 3 \\ 1 \end{bmatrix}, \lambda_1 = 2, \lambda_2 = -1, \mathbf{y} = \begin{bmatrix} 1 \\ 5 \end{bmatrix}, \mathbf{A}^{10}\mathbf{y} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}.$$

Which of the following statements are true?

- (A) $s_1 = -2045$
- (B) $s_1 = -2046$
- (C) $s_2 = 4096$
- (D) $s_2 = 4098$
- (E) $s_1 + s_2 = 2052$

17. Suppose

$$\mathbf{x} = \begin{bmatrix} -5 \\ -2 \\ 1 \\ 4 \end{bmatrix}, \mathbf{q}_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}, \mathbf{q}_2 = \begin{bmatrix} -1 \\ 1 \\ -1 \\ 1 \end{bmatrix}.$$

Let \mathbf{p} be the orthogonal projection of \mathbf{x} onto $\text{span}(\mathbf{q}_1, \mathbf{q}_2)$, and $\mathbf{p} = [p_1, p_2, p_3, p_4]^T$. Which of the following statements are true?

- (A) $p_1 = -2$ (B) $p_2 = -1$ (C) $p_3 = -2$ (D) $p_4 = -1$ (E) $p_1 + p_2 + p_3 + p_4 = 2$

18. Suppose

$$\mathbf{A} = \begin{bmatrix} 2 & 3 & 0 & 0 \\ 3 & -6 & 0 & 0 \\ 2 & 4 & 1 & 2 \\ 6 & 8 & 3 & -4 \end{bmatrix}.$$

Which of the following are eigenvalues of \mathbf{A} ?

- (A) -1 (B) -2 (C) -3 (D) -5 (E) -7

19. Suppose that $\{\mathbf{v}_1, \mathbf{v}_2, \mathbf{v}_3\}$ is a basis of V . Let \mathbf{A} be the matrix representation of the linear operator $L: V \rightarrow V$ with respect to the ordered basis $\{\mathbf{v}_3, \mathbf{v}_2, \mathbf{v}_1\}$, and

$$\mathbf{A} = \begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \\ 7 & 8 & 9 \end{bmatrix}.$$

Let $\mathbf{w} = -\mathbf{v}_1 + 2\mathbf{v}_2 + \mathbf{v}_3$ and $L(\mathbf{w}) = c_1\mathbf{v}_1 + c_2\mathbf{v}_2 + c_3\mathbf{v}_3$. Which of the following statements are true?

- (A) $c_1 = 10$ (B) $c_2 = 12$ (C) $c_3 = 18$ (D) $c_1 + c_2 + c_3 = 20$ (E) $c_1 + c_2 + c_3 = 22$

20. Let $\mathbf{x} = [x_1, x_2, \dots, x_n]^T \in \mathbb{R}^n$ and $\|\mathbf{x}\|_p = (\sum_{i=1}^n |x_i|^p)^{1/p}$ with $p = 1$ or 2 . Which of the following statements are true?

- (A) $\|\mathbf{x}\|_1 \leq 2\|\mathbf{x}\|_2$.
- (B) $\|\mathbf{x}\|_2 \leq \|\mathbf{x}\|_1$.
- (C) $\|\mathbf{x}\|_1 - \|\mathbf{y}\|_1 \leq \|\mathbf{x} - \mathbf{y}\|_1$.
- (D) $\|\mathbf{x} - \mathbf{y}\|_1 = 0$ if and only if $\mathbf{x} = \mathbf{y}$.
- (E) $\|\mathbf{x}\|_1^2 + \|\mathbf{y}\|_1^2 = \|\mathbf{x} + \mathbf{y}\|_1^2$ if \mathbf{x} is orthogonal to \mathbf{y} .

國立中山大學 112 學年度 碩士班暨碩士在職專班招生考試試題

科目名稱：控制系統【電機系碩士班乙組】

— 作答注意事項 —

考試時間：100 分鐘

- 考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
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- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：控制系統【電機系碩士班乙組】

題號：431008

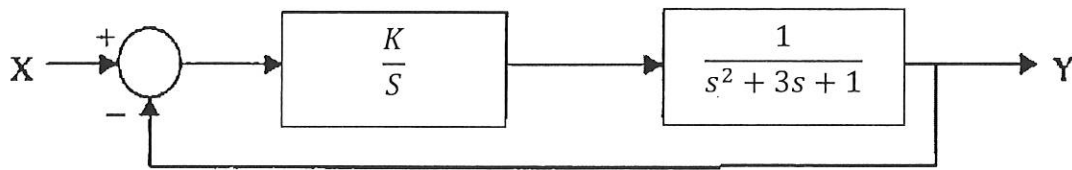
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題） 共 2 頁第 1 頁

1. Determine the number of roots that are in the right-half s -plane and on the $j\omega$ -axis for the following equations, and also determine the imaginary roots if exists.

a) $s^6 + 2s^5 + 4s^4 + 15s^3 + 8s^2 + 22s + 8 = 0$. (5 points)

b) $s^4 + s^3 + 5s^2 + 5s + 12 = 0$. (5 points)

2. Determine the value or region of K such that the following system is asymptotically stable, marginally stable, or unstable. (10 points)

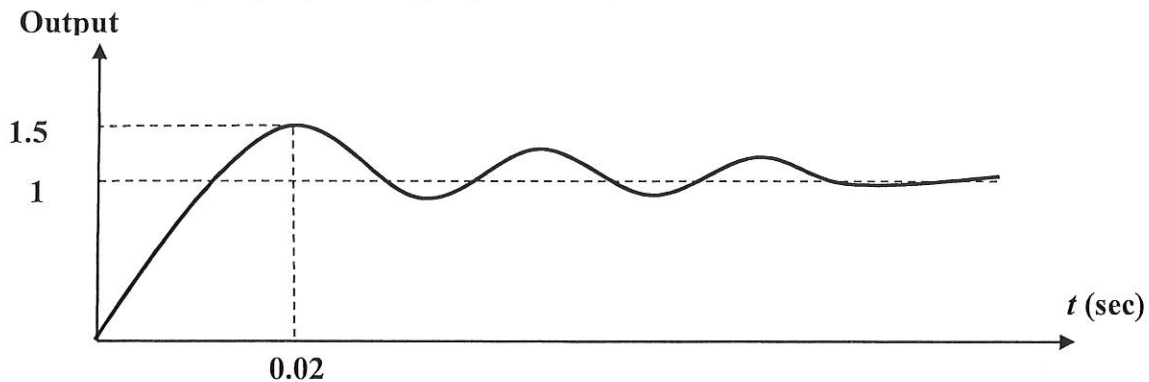


3. The unit-step response of a linear control system is shown as follows:

a) Find the transfer function of a second-order prototype system to model it. (5 points)

b) Calculate the rise time and settling time. (5 points) (rise time $t_r \cong (1.2 - 0.45 * \xi + 2.6 * \xi^2) / \omega_n$;

settling time: $t_s \cong \begin{cases} \ln(20 / \sqrt{1 - \xi^2}) / \omega_n \xi, & \text{if } 0 < \xi < 0.7 \\ (6.6\xi - 1.6) / \omega_n, & \text{if } 0.7 < \xi < 1. \end{cases}$)



4. For the following system, answer the following questions.

a) Find the intersection of the asymptotes (centroid). (1 point)

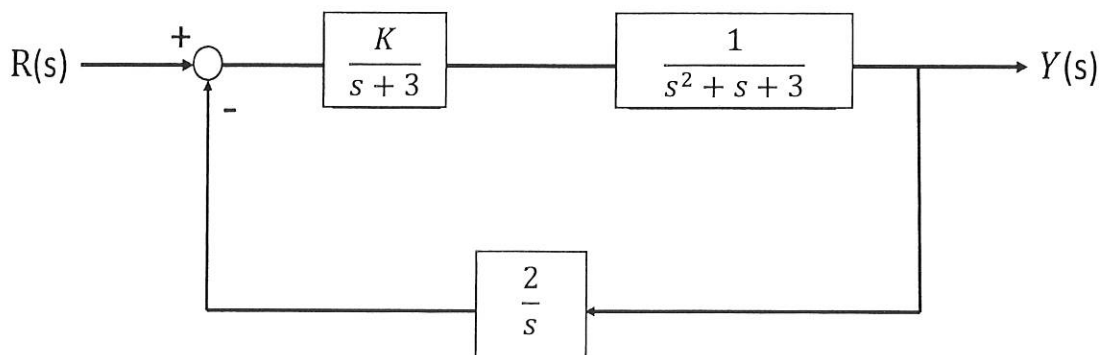
b) Determine the intersection of the root loci with the imaginary axis. (2 points)

c) Calculate the angles of departure at poles. (1 point)

d) Compute the breakaway points on real line: (1 point)

e) Sketch the root locus for the positive values of K . (3 points)

f) Describe the system stability. (2 points)



國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：控制系統【電機系碩士班乙組】

題號：431008

※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 2 頁第 2 頁

5. The transfer function of a system is given by

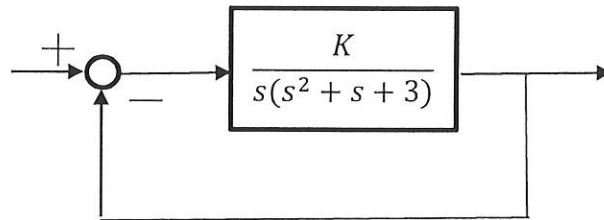
$$G(s) = \frac{1}{(s-1)(s^2-s+3)}$$

- a) Find the state-space model of the system if: $x_1 = y$, $x_2 = \dot{x}_1$ and $x_3 = \dot{x}_2$. (5 points)
- b) Design a state control feedback $u = -Kx$, with $K = [K_1 \ K_2 \ K_3]$ and such that the closed-loop poles are located at $s = -2 \pm j\sqrt{3}$ and $s = -3$. (5 points)
- c) Consider the Luenberger observer: $\dot{\hat{x}} = A\hat{x} + Bu + L(y - C\hat{x})$. Find the observer gain $L = [L_1 \ L_2 \ L_3]^T$ such that with the estimated error $e = x - \hat{x}$, $\dot{e} = (A - LC)e$ is exponentially stable with the characteristic polynomial of $(A - LC)$ being $s^3 + 2s^2 + s + 1$. (5 points)
- d) Show that the dynamic output feedback $u = -K\hat{x}$ will stabilize the original system. (5 points)

6. Consider the nonlinear system: $\dot{x}_1 = x_1^3 - x_2^3$; $\dot{x}_2 = x_1^2 - 1$, $x_1, x_2 \in \mathbb{R}$.

- a) Determine the equilibrium points. (5 points)
- b) Find the linearized systems at these equilibrium points. (5 points)

7. Consider the closed-loop system as shown in the following figure.



- a) Determine the value of the gain K such that the phase margin is 30° , and find the gain margin. (10 points)
- b) Determine the region of the gain K such that the closed-loop system is stable based on the following methods: 1) simplified Nyquist criterion (5 points); 2) Bode plot. (5 points)

8. For the unity feedback system with an open-loop transfer function

$$G(s) = \frac{3}{s(s+3)}$$

- a) Determine a PD controller such that the dominant poles of the closed-loop system are located at $-3 \pm j\sqrt{3}$. (5 points)
- b) What is the steady-state error of the compensated system with the unit ramp input? (5 points)

國立中山大學 112 學年度 碩士班暨碩士在職專班招生考試試題

科目名稱：離散數學【電機系碩士班丙組】

— 作答注意事項 —

考試時間：100 分鐘

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- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
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國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：離散數學【電機系碩士班丙組】

題號：431011

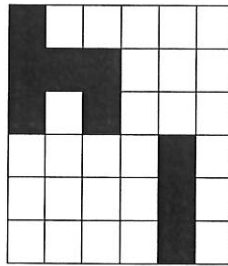
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題） 共 1 頁第 1 頁

Problem 1: If x , y , and z are natural numbers, find all the solutions (x,y,z) to the following equation. Please justify your answer. Otherwise, you get 0 points. Furthermore, write your final answer on the leftmost part of the answer paper using “Ans:” and a new individual line. You will receive mark penalty of -5 points if you fail to do so. (20pt)

$$2^x + 4^y + 8^z = 328$$

Problem 2: Assume that $\mathbb{Z}[i]$ is the ring of Gaussian integers. Besides, I is an irreducible element in the ring which divides 11213. Please list all of such irreducible elements. Note that $67^2 + 82^2 = 11213$. Please justify your answer. Otherwise, you get 0 points. Furthermore, write your final answer on the leftmost part of the answer paper using “Ans:” and a new individual line. You will receive mark penalty of -5 points if you fail to do so. (20pt)

Problem 3: Given a six-by-six matrix, where black represents forbidden cells, find the total number of combinations if six white cells (i.e., six nonforbidden cells) need to be selected. Please justify your answer. Otherwise, you get 0 points. Furthermore, write your final answer on the leftmost part of the answer paper using “Ans:” and a new individual line. You will receive mark penalty of -5 points if you fail to do so. (20 pt)



Problem 4: Find the general solution to the recurrence relation $a_n = \frac{1-n}{n} a_{n-1} + \frac{1}{n} 2^n$, where $n \geq 1$ and $a_0 = 3456$. Please justify your answer. Otherwise, you get 0 points. Furthermore, write your final answer on the leftmost part of the answer paper using “Ans:” and a new individual line. You will receive mark penalty of -5 points if you fail to do so. (20 pt)

Problem 5: Write the chromatic polynomial $P(G, \lambda)$ of the graph G by using λ colors. Please justify your answer. Otherwise, you get 0 points. Furthermore, write your final answer on the leftmost part of the answer paper using “Ans:” and a new individual line. You will receive mark penalty of -5 points if you fail to do so. (20 pt)

國立中山大學 112 學年度 碩士班暨碩士在職專班招生考試試題

科目名稱：資料結構【電機系碩士班丙組】

— 作答注意事項 —

考試時間：100 分鐘

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- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：資料結構【電機系碩士班丙組】

題號：431004

※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 3 頁第 1 頁

1. 【此題 30 分；每一小題 10 分】

- ① 我們用 $n \geq 0$ 表示演算法 A 的 input size，用 $T(n) \geq 0$ 表示演算法 A 的執行時間。假設 $T(n)$ 的時間複雜度（time complexity）為 $T(n) = \Theta(f(n))$ 。寫出 $\Theta(f(n))$ 的數學定義。
- ② 假設演算法 B 和演算法 C 都能解決問題 Q ，但演算法 B 的執行時間為 $\Theta(\log^2 n)$ ，演算法 C 的執行時間為 $\Theta(\log(\log n)!)$ ，其中 n 為 input size。假設 n 的值很大，並且我們用時間複雜度來判斷演算法的好壞，那我們該選用哪一個演算法來解決問題 Q 呢？解釋你的立論根據；直接寫答案，此一小題以 0 分計算。
- ③ 圖 1 是使用跟「C 程式語言」類似的語法描述 insertion sort，其中 D 表示陣列的名稱，其元素皆為整數，而 n 為陣列裡頭的元素數量。此一 `insertion_sort` 函式（function）能夠將陣列裡的元素由小到大排序。我們用 $T(n)$ 表示 `insertion_sort` 函式的執行時間。那麼「 $T(n) = \Theta(n^2)$ 」這樣的說法是否正確？解釋你的立論根據；若未解釋，此小題以 0 分計算。

```
void insertion_sort(int D[], int n) {
    for (int i = 1; i < n; i++) {
        int key = D[i];
        int j = i - 1;
        while ((j >= 0) and (D[j] > key)) {
            D[j + 1] = D[j];
            j--;
        }
        D[j + 1] = key;
    }
}
```

圖 1：insertion_sort 函式。

2. 【此題 25 分；第①小題 15 分，第②小題 10 分】

假設一個 binary tree，其 preorder 的拜訪次序為 $A \rightarrow B \rightarrow D \rightarrow G \rightarrow E \rightarrow C \rightarrow F$ ，其 inorder 的拜訪次序為 $G \rightarrow D \rightarrow B \rightarrow E \rightarrow A \rightarrow C \rightarrow F$ 。

- ① 請畫出此一 binary tree。註：必須寫出你推導出這棵 binary tree 的過程。直接寫答案，此小題以 0 分計算。
- ② 針對此一 binary tree，寫出 postorder 的拜訪次序。此小題可以直接寫答案。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：資料結構【電機系碩士班丙組】

題號：431004

※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 3 頁第 2 頁

3. 【此題 15 分】針對下列資料序列（sequence）

16、30、8、79、24、51

使用 heap sort 進行排序，並使得輸出結果為「由小到大」的資料序列。註：此題必須畫出排序的每個步驟；若步驟有省略，將視情況予以適量扣分。若直接寫答案，此題以 0 分計算。

4. 【此題 20 分；每一小題 10 分】

① 圖 2 為一棵 AVL tree。在圖 2 裡頭插入「73」之後的 AVL tree 為何？請畫出來。

② 承上題，在插入「73」之後，接著刪除「28」所產生的 AVL tree 為何？請畫出來。

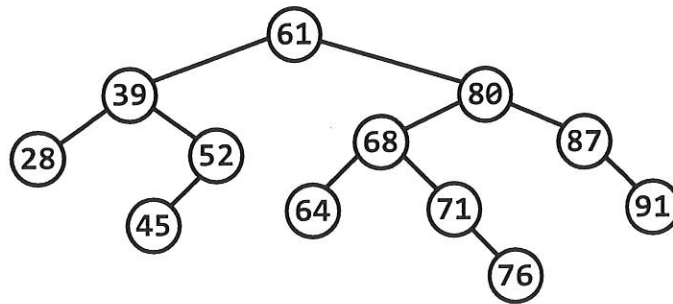


圖 2：AVL tree。

5. 【此題 10 分】圖 3 為「雙向環狀串列（doubly circular linked list，或者簡稱 doubly circular list）」的資料結構範例，其中每個 Node 的結構包含三個欄位「prev、data、next」；更具體地說，Node 的結構宣告如下：

```
struct Node {
    Node* prev; // 指向前一個 Node
    int data; // 用來儲存整數型別的資料
    Node* next; // 指向下一個 Node
};
```

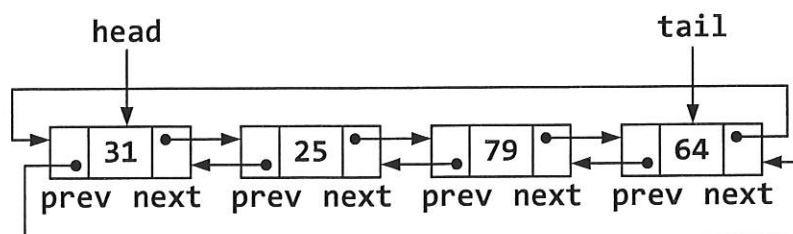


圖 3：雙向環狀串列（doubly circular linked list）的範例。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：資料結構【電機系碩士班丙組】

題號：431004

※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 3 頁第 3 頁

為了實現雙向環狀串列，我們用 C++ 程式語言宣告一個類別（class），如下：

```
class DoublyCircularList {
private:
    int numberOfNodes; // 紀錄雙向環狀串列裡頭的 Node 數量
    Node* head; // 此一指標變數永遠指向雙向環狀串列裡頭的第一個 Node
    Node* tail; // 此一指標變數永遠指向雙向環狀串列裡頭的最後一個 Node
public:
    DoublyCircularList() { // 此為預設建構式 (default constructor)
        numberOfNodes = 0;
        head = tail = nullptr;
        // nullptr 是 C++ 的關鍵字，是 null pointer 的意思
    }
    // 其餘省略
}
```

DoublyCircularList 類別裡頭包含二個指標變數：head 和 tail。如圖 3 所示，指標變數 head 永遠指向串列裡頭的第一個 Node，指標變數 tail 永遠指向串列裡頭的最後一個 Node。請幫 DoublyCircularList 類別撰寫一個成員函式（member function），其宣告為 void removeFrontNode()，其功能是将 head 指標變數所指到的 Node 刪除。註：此題限定使用 C++ 程式語言撰寫成員函式，使用其他程式語言或 pseudo code，將斟酌情況予以適量扣分。

國立中山大學 112 學年度

碩士班暨碩士在職專班招生考試試題

科目名稱：電路學【電機系碩士班丁組】

— 作答注意事項 —

考試時間：100 分鐘

- 考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
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- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電路學【電機系碩士班丁組】

題號：431006

※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 2 頁第 1 頁

1. (10 pt) Please **prove** that the Δ -connection as shown in Fig. 1(a) and the Y-connected circuit in Fig. 1(b) are equivalent, where $R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$ $R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$ $R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$.

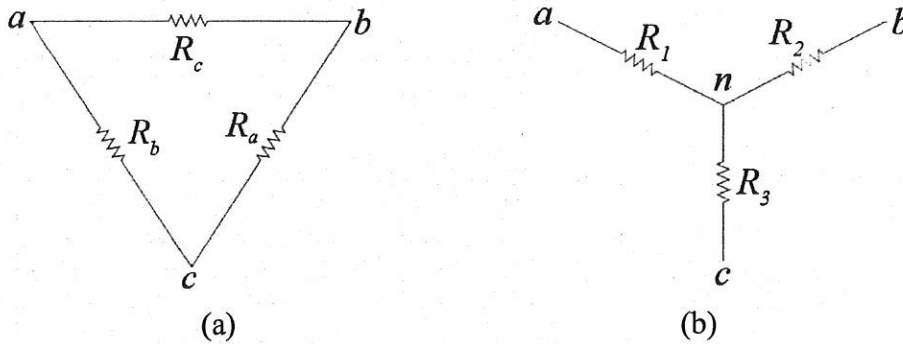


Fig. 1

2. (12 pt) For the circuit in Fig. 2(a), by adjusting the current source I_1 , the resulted V_1 can be measured and sketched in Fig. 2(b). Please find the known resistance R_x .

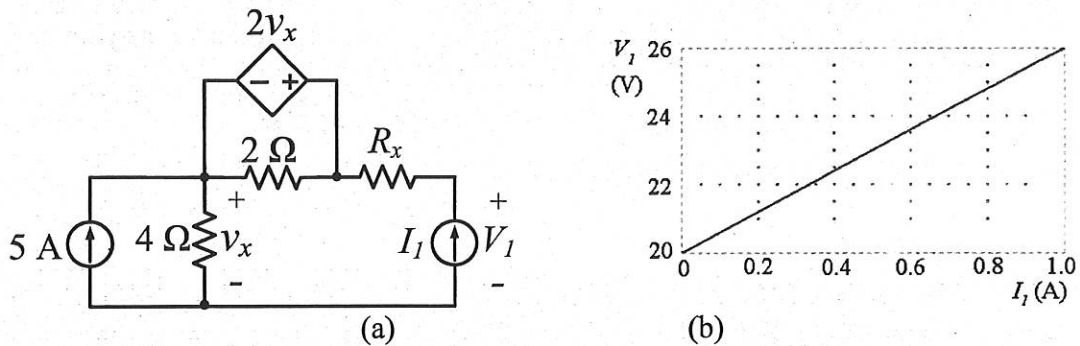


Fig. 2

3. (6 pt) Use source transformation to find I_o in Fig. 3.

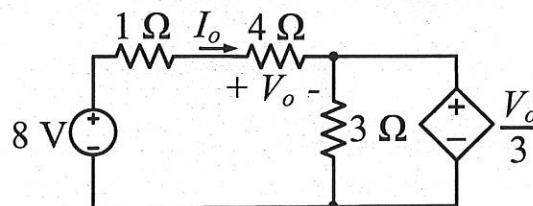


Fig. 3

4. (10 pt) Determine the value of $i_L(t)$ in Fig. 4, where $I_{in}(t) = [6 - 6u(t)]$ A, and $u(t)$ is unit step function.

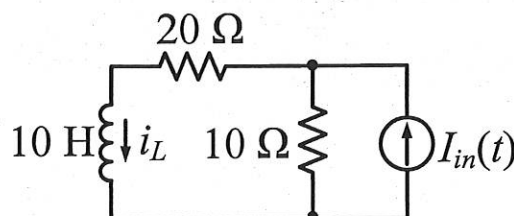


Fig. 4

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

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題號：431006

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共 2 頁第 2 頁

5. (12 pt) Determine $i_L(t)$ and $v_C(t)$ in the second-order circuit in Fig. 5.

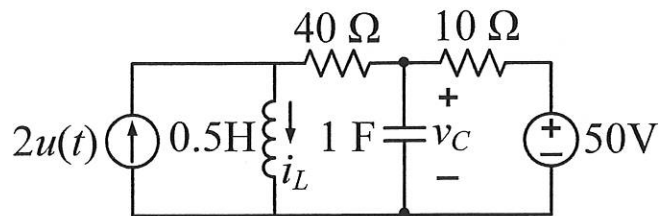


Fig. 5

6. (10 pt) In a single-phase circuit, source voltage 200V_{rms} supplies power to a load with 2kW at 0.866 power factor leading.
- (a) (5 pt) Find load current.
 - (b) (5 pt) Find load impedance
7. (20 pt) A buck converter is given with parameters: input voltage $V_g=40\text{V}$, output voltage $V_o=30\text{V}$, switching frequency $f=20\text{kHz}$, load resistance $R=4.5\ \Omega$, inductance $L=10\ \mu\text{H}$, respectively.
- (a) (5 pt) Find capacitance for output voltage ripple less than 0.1V .
 - (b) (5 pt) Find minimum inductance for continuous conduction mode (CCM).
 - (c) (5 pt) Find maximum load resistance for CCM.
 - (d) (5 pt) Find minimum output voltage for CCM.
8. (20 pt) Explain the following terminologies in power system :
- (a) (5 pt) low-voltage ride-through
 - (b) (5 pt) total harmonic distortion
 - (c) (5 pt) power-frequency droop characteristic
 - (d) (5 pt) under-frequency load shedding

國立中山大學 112 學年度

碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組、庚組、通訊所碩士班乙組選考、電波聯合碩士班選考】

— 作答注意事項 —

考試時間：100 分鐘

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- 答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 答案卡請以 2B 鉛筆劃記，不可使用修正液（帶）塗改，未使用 2B 鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。
- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組、庚組、通訊所碩士班乙組選考、電波聯合碩士班選考】題號：431002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

共 4 頁第 1 頁

下面第 1-2 題為單選題，總分 10 分。每題答對 5 分，答錯扣 5 分，未作答者以 0 分計。兩題總分低於零分者以零分計算。

- Which of the following is true about the initial value problem of $y''' - 2y'' + y' = xe^x + 5$ with $y(0) = 2$, $y'(0) = 2$ and $y''(0) = -1$? Assume that the particular solution $y_p = A_1x^{B_1}e^{C_1x} + A_2x^{B_2}e^{C_2x} + A_3x^{B_3}e^{C_3x} + A_4x^{B_4}e^{C_4x}$.
(A) $\sum_{i=1}^4(A_i + B_i + C_i) = 41/3$.
(B) $\sum_{i=1}^4(A_i + B_i + C_i) = 5$
(C) $\sum_{i=1}^4(A_i + B_i + C_i) = 38/3$.
(D) $\sum_{i=1}^4(A_i + B_i + C_i) = 14/3$.
(E) $\sum_{i=1}^4(A_i + B_i + C_i) = 8$.
- The points $\mathbf{A}(1, -2, 1)$, $\mathbf{B}(0, 1, 6)$, and $\mathbf{C}(-3, 4, -2)$ form a triangle. Find the angle ($^\circ$) between the line \mathbf{AB} and the line from \mathbf{A} to the midpoint of the line \mathbf{BC} . (Numbers are rounded to 2 decimal places).
(A) 81.29° (B) 121.51° (C) 33.89° (D) 47.40° (E) 0.83°

下面第 3-13 題為複選題，每題 5 分，總分 55 分，每題有 5 個選項，其中至少有 1 個是正確答案，答錯 1 個選項者，得 3 分，答錯 2 個選項者，得 1 分，答錯多於 2 個選項或未作答者，該題以零分計算。

- Which of the following is/are linear differential equation(s)?
(A) $xy'' + (\sin x)y = 0$
(B) $y'' + 5xy' + \sqrt{xy} = 0$
(C) $\frac{d^2x}{dt^2} = t + x^2$
(D) $\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} = u$
(E) $t^2x'' - 4tx' + 6x = \ln t^2$
- Consider the differential equation $(t - 4)^2x'' - 5(t - 4)x' = -9x$, which of the following is/are correct?
(A) It's an autonomous differential equation.
(B) The general solution is $x = c_1t^3 + c_2t^3 \ln t$.
(C) $t = 4$ is a regular singular point.
(D) The interval of definition of the general solution is $(0, \infty)$.
(E) The interval of definition of the general solution is $(-\infty, \infty)$.
- Consider the Laplace's equation $u_{xx} + u_{yy} = 0$ with the conditions listed below. According to the boundary conditions, it's possible to reduce the Laplace's equation into two simultaneous equations with respect to x and y , separately. Assume λ is the eigenvalue, identify the correct statements.
$$\begin{cases} u(0, y) = 0, & u(L, y) = 0 & 0 < y < H \\ u(x, 0) = f(x), & u(x, H) = 0 & 0 < x < L \end{cases}$$

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組、庚組、通訊所碩士班乙組選考、電波聯合碩士班選考】題號：431002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

共 4 頁第 2 頁

- (A) The Laplace's equation is elliptic.
 (B) This question is a Dirichlet problem.
 (C) The problem for X is $X'' - \lambda X = 0$, $X(0) = 0$, $X(L) = 0$.
 (D) The problem for Y is $Y'' + \lambda Y = 0$, $Y(H) = f(0)$.
 (E) The problem for Y is $Y'' + \lambda Y = 0$, $Y(H) = 0$.
6. Following question 5, which of the following is/are correct?
 (A) $\lambda = \frac{n\pi}{L}$, $X(x) = \sin\left(\frac{n\pi x}{L}\right)$, $n = 1, 2, 3, \dots$
 (B) $\lambda = \left(\frac{n\pi}{L}\right)^2$, $X(x) = \sin\left(\frac{n\pi x}{L}\right)$, $n = 1, 2, 3, \dots$
 (C) $\lambda = \frac{n\pi}{H}$, $X(x) = \sin\left(\frac{n\pi x}{H}\right)$, $n = 0, 1, 2, \dots$
 (D) The product solution is $\sin\left(\frac{n\pi x}{H}\right) \cosh\left(-\frac{n\pi(y-L)}{H}\right)$.
 (E) The product solution is $\sin\left(\frac{n\pi x}{L}\right) \sinh\left(\frac{n\pi(y-H)}{L}\right)$.
7. Which of the following is/are true about the differential equation, $y' + 2y^2 - 3y + 1 = 0$?
 (A) It is a second-order homogeneous differential equation.
 (B) There are two critical points.
 (C) One of the critical points is an attractor.
 (D) None of the critical points is an attractor.
 (E) The solution $y(x)$ increases with x when x is defined on $(1/2, \infty)$.
8. Consider the linear system $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3] \in \mathbb{R}^{5 \times 3}$, $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are column vectors of \mathbf{A} , and \mathbf{b} is a non-zero vector. Suppose $\mathbf{b} = \mathbf{a}_1 + \mathbf{a}_2 = 2\mathbf{a}_2 + \mathbf{a}_3$. Which of the following statements are true?
 (A) The linear system has exactly two solutions.
 (B) The linear system has at most two solutions.
 (C) $\text{rank}([\mathbf{A}, \mathbf{b}]) = \text{rank}(\mathbf{A}) \leq 2$.
 (D) $\mathbf{x} = [1, 3, 1]^T$ is a solution of the linear system.
 (E) The vectors $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are linearly dependent.
9. Consider the linear system $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3] \in \mathbb{R}^{3 \times 3}$, $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are column vectors of \mathbf{A} , and \mathbf{b} is a non-zero vector. Suppose

$$\mathbf{a}_1 - \mathbf{a}_2 + 3\mathbf{a}_3 = \mathbf{0}, \quad \mathbf{a}_1 + 2\mathbf{a}_2 - \mathbf{a}_3 = \mathbf{b}, \quad \text{rank}(\mathbf{A}) = 2.$$
 Which of the following are solutions of the linear system?
 (A) $\mathbf{x} = [-1, 4, -7]^T$
 (B) $\mathbf{x} = [3, 0, 5]^T$
 (C) $\mathbf{x} = [2, 4, -2]^T$
 (D) $\mathbf{x} = [3, 1, 3]^T$
 (E) $\mathbf{x} = [-2, 2, -6]^T$

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組、庚組、通訊所碩士班乙組選考、電波聯合碩士班選考】題號：431002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

共 4 頁第 3 頁

10. Two matrices are row equivalent if one can be changed to the other by a sequence of elementary row operations. Which of the following statements are true?
- (A) If there exists a matrix \mathbf{R} such that $\mathbf{B} = \mathbf{RA}$, then \mathbf{A} and \mathbf{B} are row equivalent.
 - (B) If two matrices are row equivalent, then they have the same null space.
 - (C) If two matrices are row equivalent, then they have the same eigenvalues.
 - (D) If \mathbf{E} is the reduced row echelon form of \mathbf{A} , then \mathbf{E} and \mathbf{A} are row equivalent.
 - (E) Let $\mathbf{A} \in \mathbb{R}^{m \times n}$, $\mathbf{C} \in \mathbb{R}^{m \times n}$, and $\mathbf{b} \in \mathbb{R}^m$ be given. If \mathbf{A} and \mathbf{C} are row equivalent, then the two linear systems $\mathbf{Ax} = \mathbf{b}$ and $\mathbf{Cx} = \mathbf{b}$ have the same solution set.

11. Consider the linear system $\mathbf{Ax} = \mathbf{b}$. Let $\mathbf{A} = \mathbf{QR}$, where \mathbf{Q} is an orthogonal matrix, and \mathbf{R} is an upper triangular matrix. Suppose

$$\mathbf{R} = \begin{bmatrix} -1 & 4 & 2 \\ 0 & -2 & 1 \\ 0 & 0 & 3 \end{bmatrix}, \quad \mathbf{Q}^T \mathbf{b} = \begin{bmatrix} -3 \\ 7 \\ 15 \end{bmatrix}, \quad \mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$

Which of the following statements are true?

- (A) $x_1 = 9$ (B) $x_2 = 1$ (C) $x_3 = 5$ (D) $x_1 + x_2 + x_3 = 12$ (E) $x_1 + x_2 + x_3 = 14$
12. Let $\hat{\mathbf{x}}$ be a least-squares solution of the linear system $\mathbf{Ax} = \mathbf{b}$. Which of the following statements are true?
- (A) $\hat{\mathbf{x}}$ satisfies $\mathbf{A}\hat{\mathbf{x}} = \mathbf{b}$.
 - (B) $\hat{\mathbf{x}}$ satisfies $\mathbf{A}^T \mathbf{A}\hat{\mathbf{x}} = \mathbf{A}^T \mathbf{b}$.
 - (C) $\hat{\mathbf{x}}$ always exists.
 - (D) $\hat{\mathbf{x}}$ is unique.
 - (E) $\mathbf{b} - \mathbf{A}\hat{\mathbf{x}}$ is orthogonal to any vector in the range space of \mathbf{A} .

13. Let \mathbf{x}_1 and \mathbf{x}_2 be eigenvectors of \mathbf{A} , and λ_1 and λ_2 be the corresponding eigenvalues. Suppose

$$\mathbf{x}_1 = \begin{bmatrix} -1 \\ 2 \end{bmatrix}, \quad \mathbf{x}_2 = \begin{bmatrix} 3 \\ 1 \end{bmatrix}, \quad \lambda_1 = 2, \quad \lambda_2 = -1, \quad \mathbf{y} = \begin{bmatrix} 1 \\ 5 \end{bmatrix}, \quad \mathbf{A}^{10} \mathbf{y} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}.$$

Which of the following statements are true?

- (A) $s_1 = -2045$
- (B) $s_1 = -2046$
- (C) $s_2 = 4096$
- (D) $s_2 = 4098$
- (E) $s_1 + s_2 = 2052$

以下第 14 題到第 16 題需要詳明推導計算過程。如推導計算過程錯誤，將酌扣分數或不給分。第 15-16 題中， $j = \sqrt{-1}$ 。

14. (10%) Use the Laplace transform to solve the following initial value problem.

$$y'' + 6y' + 9y = e^{-3t} \cos t, \quad y(0) = 0, \quad y'(0) = 0$$

15. (10%) The Fourier transform of a continuous-time real function is given as

$$Y(j\omega) = \int_{-\infty}^{+\infty} y(t)e^{-j\omega t} dt.$$

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組、庚組、通訊所碩士班乙組選考、電波聯合碩士班選考】題號：431002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

共 4 頁第 4 頁

(a) Obtain the Fourier transform of the following function. (5%)

$$y(t) = \left(\frac{\sin 100\pi t}{\pi t} \right)^2$$

(b) To sample $y(t)$ with equal interval, what is the maximal sampling period T to possibly prevent from aliasing? (5%)

16. (15%) Let C be the circle $|z^* + j| = 2$ oriented in a positive sense where z^* indicates the complex conjugate of z , and a complex integral is defined as

$$g(z_0) = \int_C \frac{z^2 - z_0}{z^2 + z_0} dz$$

(a) Illustrate the contour C on a complex plane. Find $g(4)$. (10%)

(b) Find $g(10)$. (5%)

國立中山大學 112 學年度

碩士班暨碩士在職專班招生考試試題

科目名稱：計算機結構【電機系碩士班已組】

— 作答注意事項 —

考試時間：100 分鐘

- 考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- 答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 答案卡請以 2B 鉛筆劃記，不可使用修正液（帶）塗改，未使用 2B 鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
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- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：計算機結構【電機系碩士班已組】

題號：431007

※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 3 頁第 2 頁

4. [25%] The following MIPS assembly codes show a simple program regarding the three data arrays, $X[i]$, $Y[i]$, and $Z[i]$. All the numbers specified in the instruction set are represented as the decimal format. We know that the base address of $X[i]$, $Y[i]$, and $Z[i]$ is stored in $\$a0$, $\$a1$, and $\$a2$, respectively. In addition, only the first element in each of data arrays is non-zero, such as $X[0] = 36$, $Y[0] = 21$, and $Z[0] = 41$; other elements are all-zeros. Please answer the following questions.
- (5%) Please calculate $Y[3]$.
 - (5%) After executing this program, please find out N when $X[N] > 0$ and $X[N+1] = 0$.
 - (5%) According to the result in (b), please calculate $X[N]$.
 - (5%) According to the result in (b), please calculate $Y[N]$.
 - (5%) According to the result in (b), please calculate $Z[N]$.

<i>0x100</i> <code>sub \$t0, \$0, \$0</code>	<i>0x130</i> <code>sub \$t6, \$t6, \$t4</code>
<code>ori \$s0, \$0, 9</code>	<code>srl \$t7, \$t3, 1</code>
<code>sll \$t1, \$t0, 2</code>	<code>add \$t7, \$t7, \$t4</code>
<code>add \$s1, \$a0, \$t1</code>	<code>sw \$t7, 4(\$s1)</code>
<i>0x110</i> <code>add \$s2, \$a1, \$t1</code>	<i>0x140</i> <code>sw \$t6, 4(\$s2)</code>
<code>add \$s3, \$a2, \$t1</code>	<code>sw \$t5, 4(\$s3)</code>
<code>lw \$t2, 0(\$s1)</code>	<code>addi \$t0, \$t0, 1</code>
<code>lw \$t3, 0(\$s2)</code>	<code>bne \$s0, \$t0, -72</code>
<i>0x120</i> <code>lw \$t4, 0(\$s3)</code>	<i>0x150</i> <code>EXIT</code>
<code>andi \$t5, \$t3, 7</code>	
<code>add \$t5, \$t2, \$t5</code>	
<code>sll \$t6, \$t2, 1</code>	

5. [20%] Figure 1 depicts a multi-cycle MIPS CPU implementation. A program takes 60 clock cycles in total, as listed in TABLE II. All the instructions utilized only belong to the categories of {R-type, SW, LW, BEQ, Jump}. All the control signals are specified in the decimal format and "X" denotes "don't care". According to Figure 1 and TABLE II, please answer the following questions.
- (4%) What is the total number of instructions used for this program?
 - (4%) Please show the single-bit value of "lorD" at 33rd clock cycle.
 - (4%) Please show the 2-bit binary value of "PCsource" at 47th clock cycle.
 - (4%) "opcode" is the most important for deciding what instruction is decoded currently. It has 6 bits in the 32-bit instruction format, such as Bit [31:26]. What is the decimal value of "opcode" for the instruction executed at 13th clock cycle?
 - (4%) What is the number of SW instruction?

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：計算機結構【電機系碩士班已組】

題號：431007

※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 3 頁第 3 頁

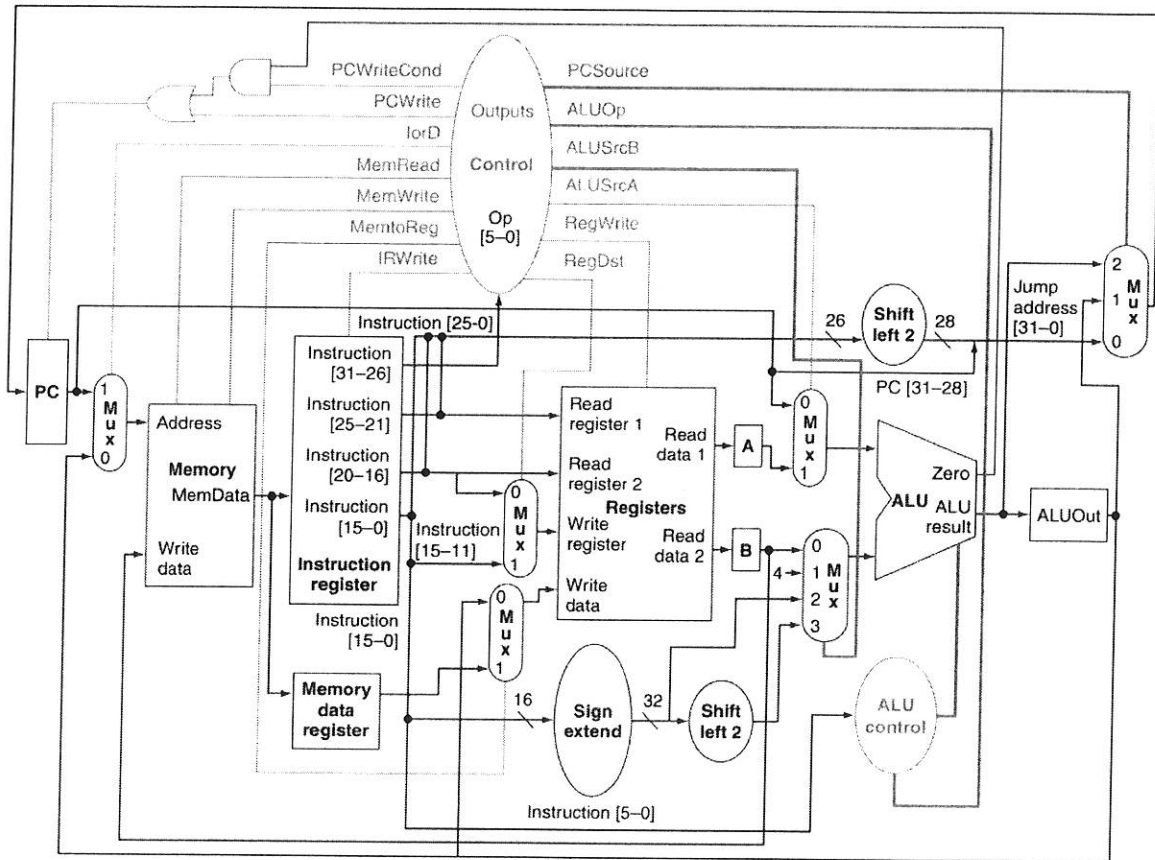


Figure 1

TABLE II

Cycle index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ALUSrcA	0	0	1	X	0	0	1	X	0	0	1	X	X	0	0	1	X	0	0	1
ALUSrcB	1	3	0	X	1	3	0	X	1	3	2	X	X	1	3	0	X	1	3	0
MemRead	1	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0

Cycle index	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
ALUSrcA	X	0	0	1	X	X	0	0	1	X	0	0	1	X	0	0	1	X	0	0
ALUSrcB	X	1	3	2	X	X	1	3	2	X	1	3	0	X	1	3	0	X	1	3
MemRead	0	1	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0

Cycle index	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
ALUSrcA	1	0	0	1	X	X	0	0	X	0	0	1	0	0	1	X	0	0	1	X
ALUSrcB	0	1	3	2	X	X	1	3	X	1	3	0	1	3	2	X	1	3	0	X
MemRead	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0	0	1	0	0	0

國立中山大學 112 學年度

碩士班暨碩士在職專班招生考試試題

科目名稱：通訊理論【電機系碩士班戊組選考、通訊所碩士班甲組、乙組選考、電波聯合碩士班選考】

— 作答注意事項 —

考試時間：100 分鐘

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國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：通訊理論【電機系碩士班戊組選考、通訊所碩士班甲組、乙組選考、電波聯合碩士班選考】題號：437002

※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 2 頁第 1 頁

1. (10%) Consider a message signal $m(t)$ containing frequency components respectively at 100, 200, and 400 Hz. This signal is applied to an SSB modulator together with a carrier at 100 kHz, with only the upper sideband retained. In the coherent detector used to recover $m(t)$, the local oscillator supplies a sine wave of frequency 100.02 kHz.
- (A) Determine the frequency components of the detector output. (5%)
- (B) Repeat your analysis by assuming that only the lower sideband is transmitted. (5%)

2. (15%) For each of the following systems, determine whether the system is (1) linear, (2) time invariant, and (3) causal. Please write the answers in detail.
- (A) $y(t) = \cos(3t)x(t)$ (5%)
- (B) $y(t) = \int_{-\infty}^{2t} x(\tau)d\tau$ (5%)
- (C) $y(t) = \begin{cases} 0, & x(t) < 0 \\ x(t) + x(t+2), & x(t) \geq 0 \end{cases}$ (5%)

3. (15%) Consider the low-pass equivalent representation of a signal

$$u(t) = \sum_{n=-\infty}^{\infty} I_n g(t - nT)$$

where

$$g(t) = \begin{cases} A, & 0 \leq t \leq T \\ 0, & \text{otherwise} \end{cases}$$

$$I_n = a_n - \frac{1}{\sqrt{3}}a_{n-1}$$

and $\{a_n\}$ is a sequence of uncorrelated QPSK symbols that occur with equal probability and $E[|a_n|^2] = 1$.

- (A) Determine the autocorrelation function of $\{I_n\}$ (10%)
- (B) Determine the power spectral density of $u(t)$ (5%)
4. (15%) A bit error rate of $P_b = 10^{-3}$ is required for a system with a data rate of 100 Kbps to be transmitted over an AWGN channel using coherently detected MPSK modulation. The system bandwidth is 50kHz. Assume that the system frequency transfer function is a raised cosine with a roll-off characteristic of $r = 0.5$ and a Gray code is used for the symbol to bit assignment. What E_b/N_0 is required for the specified P_B ? (Hint: $Q(1.5 \times 10^{-3}) = 2.96$)

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：通訊理論【電機系碩士班戊組選考、通訊所碩士班甲組、乙組選考、電波聯合碩士班選考】題號：437002

※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 2 頁第 2 頁

5. (25%) Three messages are transmitted equiprobably over an AWGN channel with noise PSD = $N_0/2$:

$$s_1(t) = \begin{cases} 2, & 0 \leq t \leq T/2, \\ -2, & T/2 < t \leq T, \\ 0, & \text{otherwise.} \end{cases}$$

$$s_2(t) = \begin{cases} \sqrt{2} + 1, & 0 \leq t \leq T/2, \\ \sqrt{2} - 1, & T/2 < t \leq T, \\ 0, & \text{otherwise.} \end{cases}$$

$$s_3(t) = \begin{cases} -\sqrt{2} + 1, & 0 \leq t \leq T/2, \\ -\sqrt{2} - 1, & T/2 < t \leq T, \\ 0, & \text{otherwise.} \end{cases}$$

(A) Use the Gram-Schmidt orthogonalization procedure to find an orthonormal basis for this set of signals. (10%)

(B) Draw the signal constellation of the ternary messages. (5%)

(C) Sketch the optimal decision regions R_1 , R_2 , and R_3 . (Please label the decision boundaries clearly) (5%)

(D) Design the receiver. (5%)

6. (20%) For a binary transmission system, $s_i(t)$, $i = 0$ or 1 , is the transmitted signal, $n(t)$ is the additive noise, $r(t)$ is the received signal and $r(t) = s_i(t) + n(t)$ for each symbol duration T . The output of the correlator receiver is $z(T) = a_i + n_0$. The signal component a_i is $a_0 = -1$ or $a_1 = 1$, and the noise component n_0 has a probability density function of $p(n_0) = \left(\frac{1}{2}\right) \Lambda\left(\frac{n_0}{2}\right)$.

(A) If $s_1(t)$ and $s_2(t)$ are transmitted with an equal probability, determine the value of the optimum decision threshold and the bit error probability. (10%)

(B) If $s_1(t)$ are transmitted with a probability of 0.8, determine the value of the optimum decision threshold and the bit error probability. (10%)

國立中山大學 112 學年度

碩士班暨碩士在職專班招生考試試題

科目名稱：電子學【電機系碩士班戊組選考、通訊所碩士班乙組選考、電波聯合碩士班選考】

— 作答注意事項 —

考試時間：100 分鐘

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國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電子學【電機系碩士班戊組選考、通訊所碩士班乙組選考、電波聯合碩士班選考】題號：482003

※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 2 頁第 1 頁

1. (15%) A fourth-order filter has zero transmission at $\omega = 0$, $\omega = 2$ rad/s, and at $\omega = \infty$. The natural modes are $-0.1 \pm j0.5$ and $-0.1 \pm j1.5$. Find the transfer function $T(s)$. (*Hint*: The natural modes are the time functions corresponding to the poles.) (15%)

2. (35%) Consider the common-emitter amplifier of Fig. 1 under the following conditions: $R_s = 5$ k Ω , $R_1 = 33$ k Ω , $R_2 = 22$ k Ω , $R_E = 3.9$ k Ω , $R_C = 4.7$ k Ω , $R_L = 5.6$ k Ω , $V_{CC} = 5$ V. The dc emitter current can be shown to be $I_E \approx 0.33$ mA, at which $\beta_0 = 120$, $r_o = 300$ k Ω , and $r_x = 50$ Ω .
 - (a) Find the input resistance, R_{in} . (*Hint*: $R_{in} = R_1 \parallel R_2 \parallel (r_x + r_\pi)$) (10%)
 - (b) Find the midband gain, A_M . (10%)
 - (c) For $C_{C1} = C_{C2} = 1$ μ F and $C_E = 10$ μ F, estimate the low-frequency 3-dB frequency. Also find the frequency of the zero introduced by C_E . (15%)

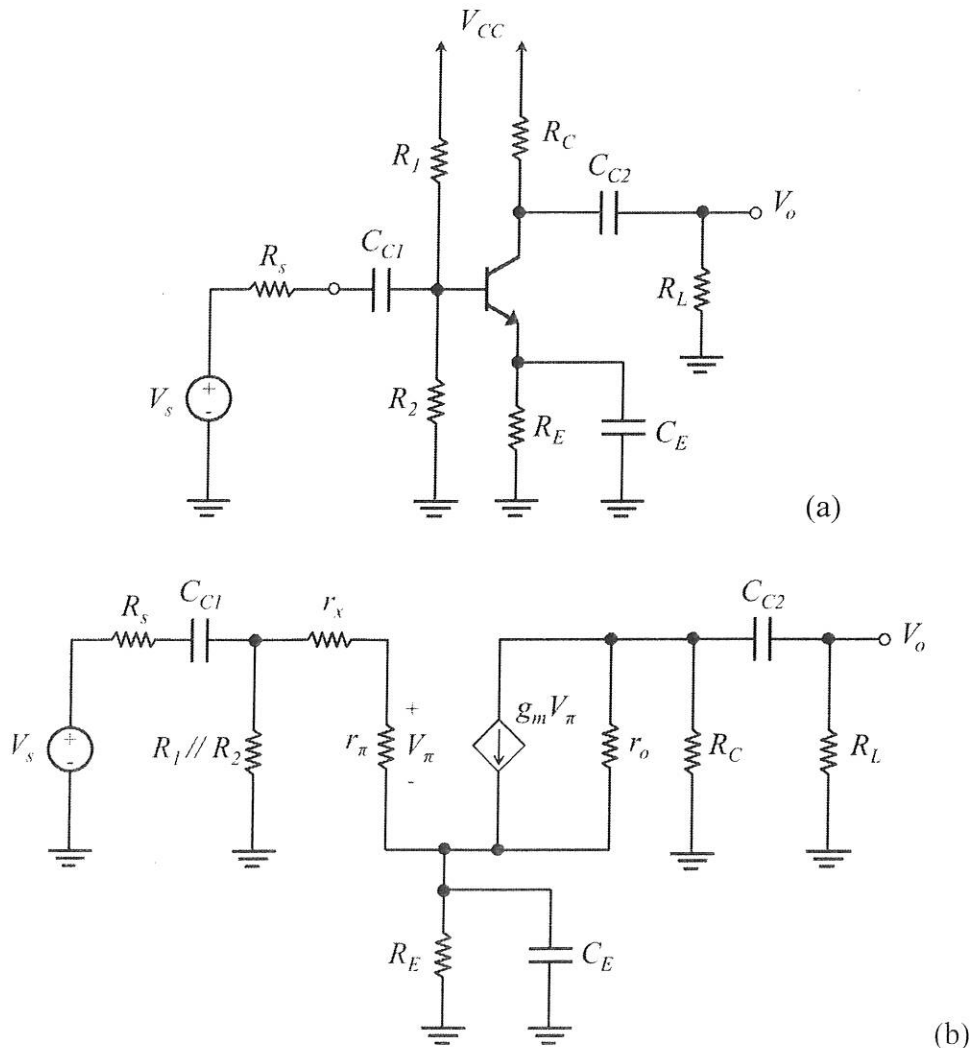


Figure 1. (a) common-emitter amplifier stage; (b) Equivalent circuit for the amplifier of Fig. 1(a) in the low-frequency band.

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電子學【電機系碩士班戊組選考、通訊所碩士班乙組選考、電波聯合碩士班選考】題號：482003

※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 2 頁第 2 頁

3. (20%) Design the circuit of Fig. 2 so that the transistor operates at $I_D = 0.4 \text{ mA}$ and $V_D = +1 \text{ V}$. The NMOS transistor has $V_t = 2 \text{ V}$, $\mu_n C_{ox} = 20 \mu\text{A}/\text{V}^2$, $L = 10 \mu\text{m}$, and $W = 400 \mu\text{m}$. Neglect the channel-length modulation effect (i.e., assume that $\lambda = 0$).
- (a) Find R_S . (10%)
 (b) Find R_D . (10%)

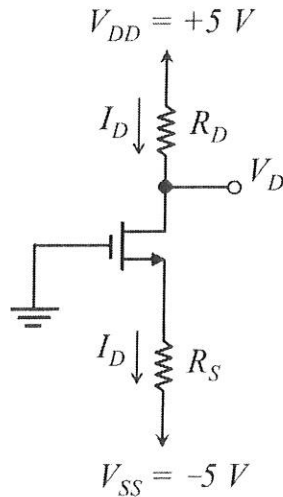


Figure 2.

4. (30%) For the circuit shown in Fig. 3, find the values of the labeled node voltages for :
- (a) $\beta = \infty$. (15%)
 (b) $\beta = 100$. (15%)

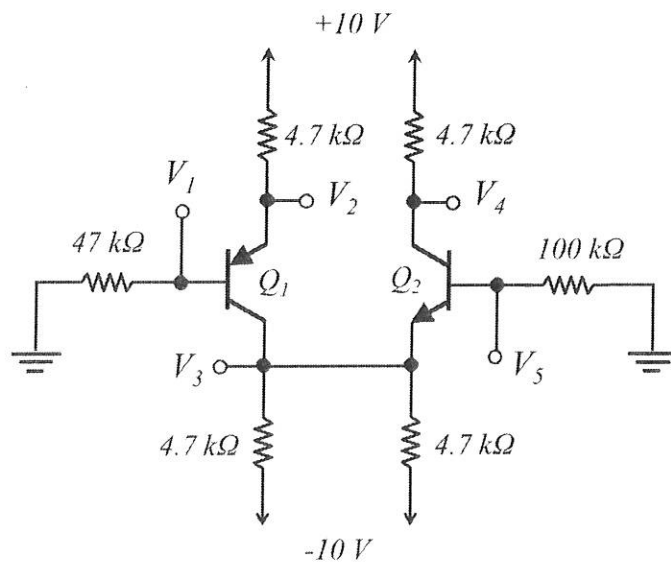


Figure 3.

國立中山大學 112 學年度 碩士班暨碩士在職專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、通訊所碩士班乙組、電波聯合碩士班】

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考試時間：100 分鐘

- 考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- 答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請斟酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 答案卡請以 2B 鉛筆劃記，不可使用修正液（帶）塗改，未使用 2B 鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。
- 試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。
- 試題採雙面列印，考生應注意試題頁數確實作答。
- 違規者依本校招生考試試場規則及違規處理辦法處理。

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、通訊所碩士班乙組、電波聯合碩士班】題號：482004
 ※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 2 頁第 1 頁

- (25%) The length of a coaxial cable with outer and inner conductors is L . The space between the outer conductor of inner radius a and the inner conductor of radius b is filled by a medium with permittivity ϵ and conductivity σ . The leakage resistance between these two conductors is R and the capacitance of this cable is C . Determine RC .
- (25%) The rectangular and circular loops are coplanar as shown in Fig. 1. The radius of the circular loop is c . Determine the mutual inductance between these two loops. Assume that $b \gg c$ and $c > d$.

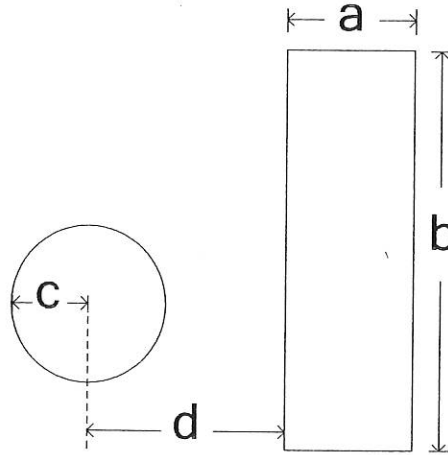


Fig. 1

- (5%) (a) Write Maxwell's equations in differential form.
 (5%) (b) Write the EM boundary conditions.
 (5%) (c) Explain homogeneous Helmholtz's equation.
 (5%) (d) Explain dispersion.
- As shown in Fig. 2, a uniform plane wave ($\mathbf{E}_i, \mathbf{H}_i$) of an angular frequency ω is incident from air on a very large, perfectly conducting wall at an angle of incidence θ_i with perpendicular polarization. Find
 (5%) (a) the current induced on the wall surface, and
 (5%) (b) the time-average Poynting vector in medium 1.

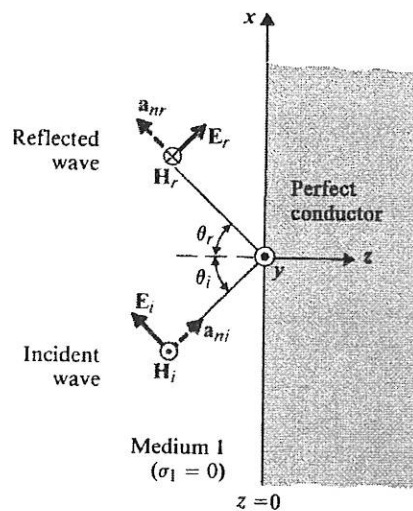
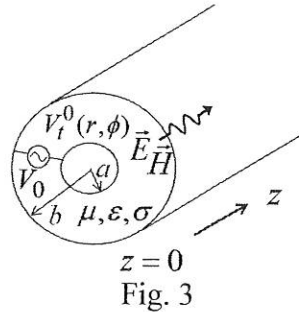


Fig. 2

國立中山大學 112 學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、通訊所碩士班乙組、電波聯合碩士班】題號：482004
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5. (10%) As shown in Fig. 3, for a coaxial line in TEM mode, find \mathbf{E} and \mathbf{H} .



6. The open-circuit and short-circuit impedance at the input terminals of a lossless transmission line of length 1.5 (m), which is less than a quarter wavelength, are $-j54.6 \text{ } (\Omega)$ and $j103 \text{ } (\Omega)$, respectively.
- (4%) Find Z_0 and γ of the line.
- (4%) Without changing the operating frequency, find the input impedance of a short-circuited line that is twice the given length.
- (2%) How long should the short-circuited line be in order for it to appear as an open circuit at the input terminals?