國立中正大學
111學年度碩士班招生考試
試 題

[第1節]

科目名稱	電磁學
系所組別	電機工程學系-電磁晶片組

－作答注意事項－

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國立中正大學 111 學年度碩士班招生考試試題

科目名稱：電磁學　　本科目共 3 頁　第 1 頁

系所組別：電機工程學系-電磁晶片組

1. (8%) The potential field in a uniform material with dielectric constant $\varepsilon_r = 80$ is $V = 2x^2y^4$ (V). Find
   (a) (4%) The electric field intensity $\vec{E}$.
   (b) (4%) The polarization vector $\vec{P}$.

2. (12%) A boundary separating two dielectric media with permittivities $\varepsilon_1 = 23\varepsilon_0$ ($z > 0$) and $\varepsilon_2 = 4\varepsilon_0$ ($z < 0$) lies in the x-y plane. The boundary has a surface charge density $\rho_s = 2.653\times10^{-10}$ C/m^2 and the electric field intensity in medium 1 at the boundary is $\vec{E}_1 = \hat{a}_x 5 + \hat{a}_y 10 + \hat{a}_z 2$ (V/m). Find:
   (a) (4%) The tangential electric field in medium 2.
   (b) (4%) The normal electric field in medium 2.
   (c) (4%) The angle between $\vec{E}_2$ and z axis.

3. (10%) A coaxial cable as shown in Fig. 1 consists of two concentric, conducting cylindrical surfaces of inner and outer radii a and b, respectively. An insulating material of dielectric constant ε_r fills the space between the two surfaces. Two charges $+Q$ and $-Q$ uniformly distribute on the inner and outer surfaces. Given $\varepsilon_r = 2.3$, $a = 0.5$ cm, $b = 2$cm, $l = 100$ cm, and $Q = 0.2$ nC. determine:
   (a) (3%) The electric field in the dielectric medium.
   (b) (3%) The unit-length capacitance of the cable.
   (c) (4%) The stored electrostatic energy in the dielectric medium

4. (12%) An infinitely long conductor wire carrying current I is situated next to a rectangular loop as shown in Fig. 2. Given $I = 5$ A, $d = 1$ cm, $a = 2$ cm, $b = 8$ cm, determine:
   (a) (4%) The net magnetic force acting on the loop.
   (b) (4%) The magnetic flux that penetrates the loop.
   (c) (4%) The mutual inductance between the wire and the loop.

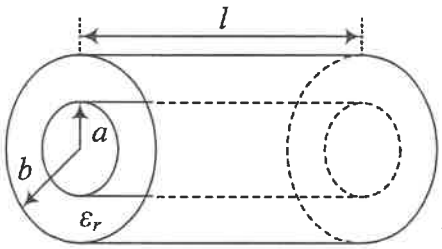

Fig. 1

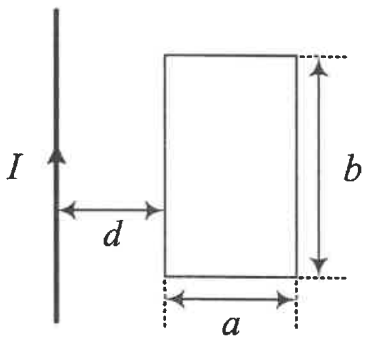

Fig. 2

5. (8%) Two infinite insulated conducting plates maintained at potentials 0 and V_0 form a wedge-shaped configuration, as shown in Fig. 3. Determine the potential distributions for the regions:
   (a) (4%) $0 < \phi < \alpha$
   (b) (4%) $\alpha < \phi < 2\pi$

6. (18%) A 75-Ω transmission line is terminated with a complex impedance $Z_L = 45 + j60$. Please determine:
   (a) (3%) Is this load an inductive load or capacitive load?
   (b) (3%) The load reflection coefficient Γ_L.
   (c) (3%) The voltage standing wave ratio VSWR?
   (d) (3%) Find the first V_{min} position nearest to the load (in wavelength).
   (e) (6%) To match this load, please design your matching network that includes a quarter-wavelength transformer.

7. (10%) In a material for which conductivity $\sigma = 6$ S/m and $\varepsilon_r = 4$, the electric field intensity is $\vec{E}(t) = 150 \sin(10^{10}t)$ (V/m). Find:
   (a) (3%) Conductor current J_c
   (b) (3%) Displacement current J_d
   (c) (4%) The frequency (Hz) at which J_c and J_d have equal magnitude

8. (10%) Consider a light ray normally incidents on one side of the 45°-90°-45° right-angled prism (ε_r=2.3), and exits the prism through two reflective surfaces. Assume that due to manufacturing error, one of the angles of this prism is 46°, and the other complementary angle is 44°, as shown in Fig. 4. Determine the angle θ where the light exits the prism. (hint: sin(46°)=0.719)

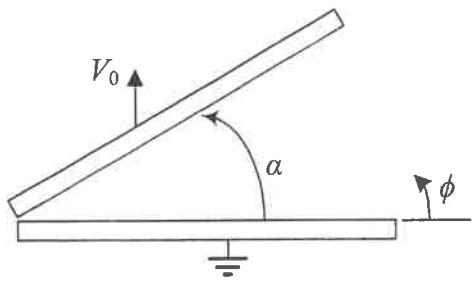

Fig. 3

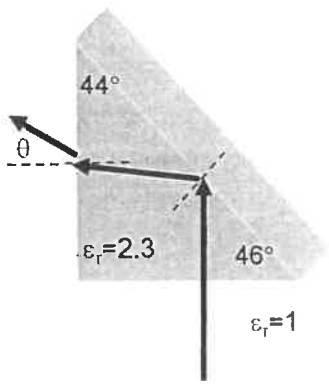

Fig. 4

9. (12%) Please answer the following questions:
   (a) (4%) Will it make sense to define VSWR in a conductive medium? Cite reasons to justify your answers.
   (b) (4%) Why is the underwater communication using EM wave so difficult? Cite reasons to justify your answers.
   (c) (4%) The ray trace between the satellite (in space) and GPS antenna (on earth surface) is likely shown as below (Fig. 5). Why is it a curved path instead of a straight path? Cite reasons to justify your answers.

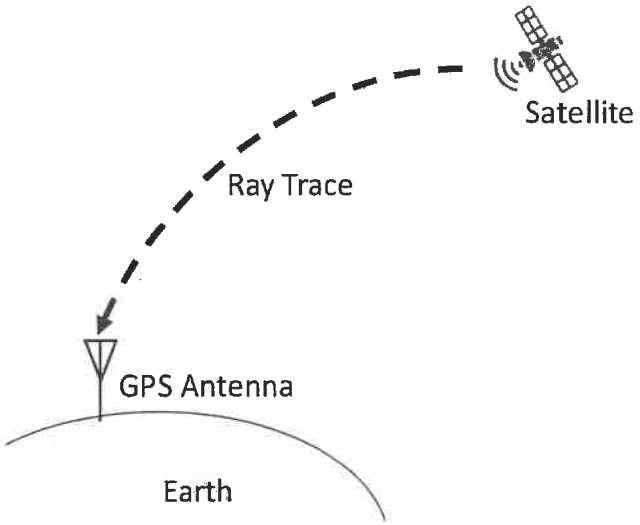

Fig. 5

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試 題

[第 1 節]

科目名稱	計算機組織
系所組別	電機工程學系－ 計算機工程組 晶片系統組

－作答注意事項－

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國立中正大學 111 學年度碩士班招生考試試題

科目名稱：計算機組織　　本科目共 2 頁　第 1 頁

系所組別：電機工程學系-計算機工程組、晶片系統組

1. (20%) Draw a single-cycle datapath for MIPS R-type instructions SW and BNE (including instruction decoder and control signals to multiplexors and state elements).

2. (25%) Given a 32-bit machine with byte-addressable memories.

   (a) (10%) Draw a four-way set-associative cache that has a total of 1024 lines with one word per line.

   (b) (5%) Calculate the total amount of cache memory in bytes.

   (c) (10%) Find the binary values of (1)tag, (2)index, and (3)byte-offset for byte address 1200 in the cache of (a).

3. (25%) Assume a 5-stage pipelined processor similar to MIPS is going to execute the following code fragment.

```
Loop: LW    R2, 0(R1)
      ADDI  R1, R1, 4
      ADD   R3, R3, R2
      SUBI  R4, R4, 1
      BNEZ  R4, Loop      # if R4 != 0 go to Loop
```

   The initial value of R4 is 10. Assume that all possible forwarding paths are present in the pipeline. The cache is direct-mapped with a line size of 4 words. Initially the cache has all entries marked as invalid. The cache has a 1-cycle hit time and takes an additional 10 cycles on a cache miss. The branch prediction unit predicts each branch as the same as its last seen outcome. Each branch mis-prediction yields a 2-cycle penalty.
   Note: answers without clear reasoning are unacceptable!

   (a) (15%) What is the runtime in cycles to execute the above code?

   (b) (5%) If the order of the ADDI and ADD instructions is switched in the code shown above, will the runtime change? If so, by how much?

   (c) (5%) If the order of the ADD and SUBI instructions is switched in the code shown above, will the runtime change? If so, by how much?

4. (30%) Assume a fully-connected neural network containing 1 input layer, 3 hidden layers, and 1 output layer.

   - The input layer has 256 nodes, each of which represents an 8-bit pixel of a 16*16 grayscale image.

- Each of the 3 hidden layers contains 256 neurons, which computes a weighted sum of all nodes in its precedent layer, adds a bias value, and performs ReLU activation (i.e. the result remains the same if it is positive; otherwise it becomes 0). In other words, the j-th neuron of the i-th layer: $x_{i,j}$ compute $max(\sum_{k=0}^{255} x_{i-1,k} \times w_{i,j,k} + b_{i,j}, 0)$.
- The output layer has 10 nodes, each of which represents a digit (i.e. 0, 1, 2, … , 9). The j-th output node $x_{4,j}$ computes $\sum_{k=0}^{255} x_{3,k} \times w_{4,j,k} + b_{4,j}$ without ReLU.

(a) (5%) What is the amount of storage (in bytes) that are needed if the weights and biases are both represented as IEEE 754 single-precision floating-point numbers?

(b) (10%) Due to cost issues, only a 1KByte SRAM is allowed to store the weights on chip (assume biases are handled independently), and the design team decides to implement a direct-mapped cache mechanism to simplify the management of on-chip (i.e. 1Kbyte SRAM) and off-chip (i.e. containing all weights) storages. Assume one cache block stores 32-byte data. What are the on-chip storage requirements in addition to the 1Kbyte SRAM for weights?

(c) (5%) What is the miss rate of the weight cache in (b)?

(d) (10%) Describe how to improve the weight memory organization in (b) under the same cost constraint. Note: answers without clear reasoning are unacceptable!

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試 題

[第1節]

科目名稱	電路學
系所組別	電機工程學系-電力與電能處理甲組

—作答注意事項—

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國立中正大學 111 學年度碩士班招生考試試題

科目名稱：電路學　　本科目共 2 頁　第 1 頁

系所組別：電機工程學系-電力與電能處理甲組

1. Please determine R_L to obtain the maximum power transfer. Please also calculate the maximum power transfer P_{max} (20%)

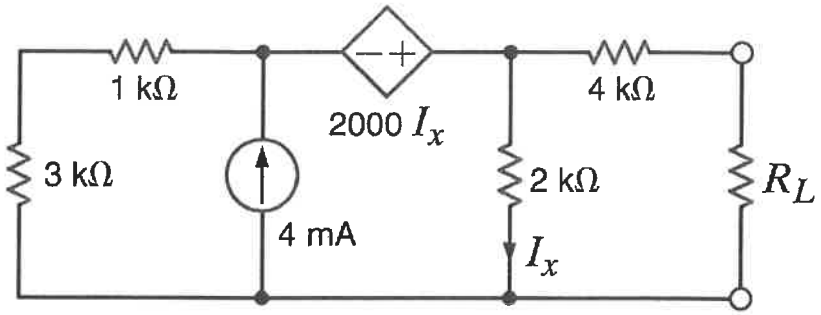

Fig.1

2. Please find the total energy stored in Fig.2 (20%)

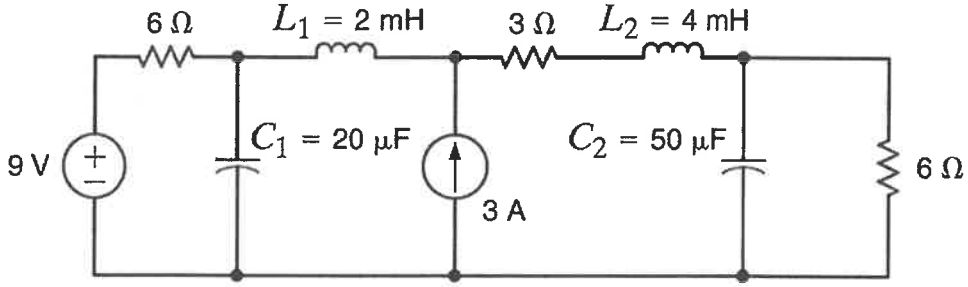

Fig. 2

3. Please find *Vo(t)* in Fig. 3 when t>0 (20%)

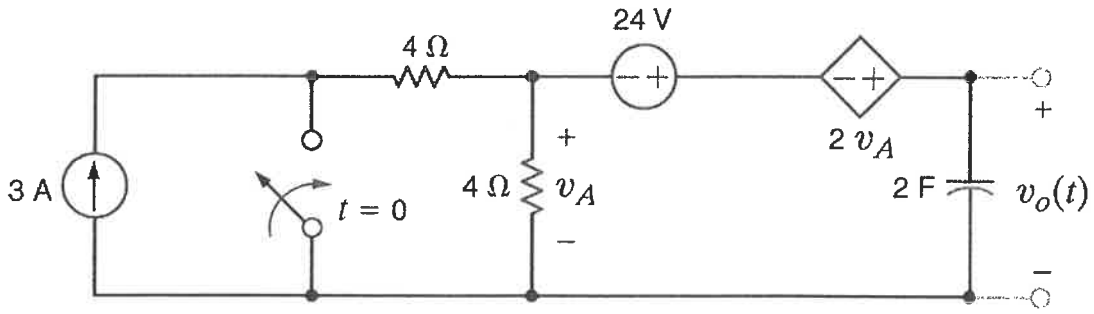

Fig. 3

4. Please find the current *i(t)* in Fig. 4 in steady state. (20%)

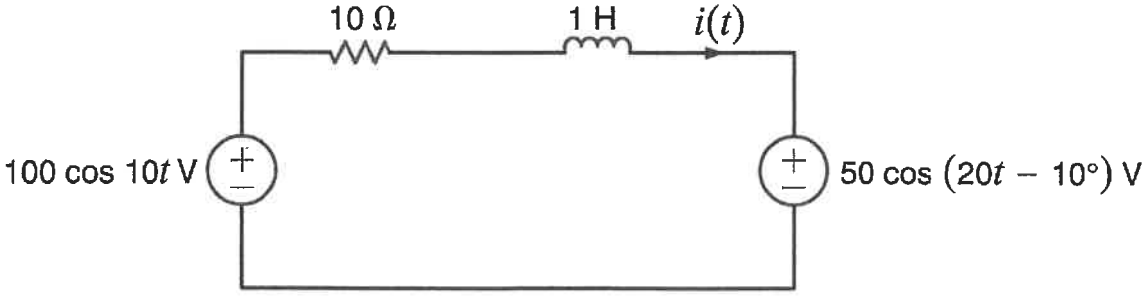

Fig. 4

5. Please determine line currents (I_{aA}, I_{bB} and I_{cC}) in Fig. 5. (20%)

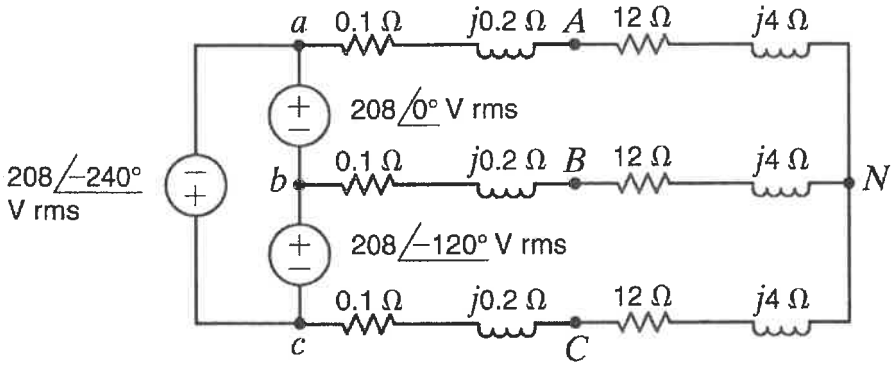

Fig. 5

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111 學年度碩士班招生考試
試 題

[第 1 節]

科目名稱	控制系統
系所組別	電機工程學系-電力與電能處理甲組

－作答注意事項－

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國立中正大學 111 學年度碩士班招生考試試題

科目名稱：控制系統　　本科目共 1 頁　第 1 頁

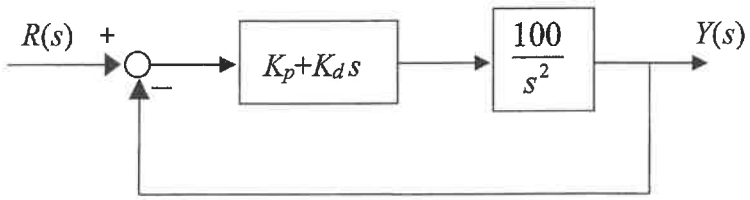
系所組別：電機工程學系-電力與電能處理甲組

1. (30%) A PD control system is shown in the following figure. Construct a parameter plane of K_p versus K_d (K_p is the vertical axis) and show the following trajectories.

(a) Trajectories on which the damping is critical.

(b) Trajectories on which the parabolic-error constant is 1000.

(c) Trajectories on which the system is pole-zero cancellation.



2. (50%) Given a closed-loop unity-feedback control system described by the state equations

$$\dot{x}=\begin{bmatrix}-2 & -1 & 0\\ 0 & 0 & -1\\ -K & 0 & -10\end{bmatrix}x$$

(a) Apply the Nyquist criterion to determine the range of K so that the system is asymptotically stable.

(b) Check the answer obtained in part (a) with the Routh-Hurwitz criterion.

(c) Construct the root locus for $K \geqq 0$.

(d) Find the value of K so that the gain margin of the system is 20 dB.

(e) Find the value of K so that the phase margin of the system is 45°.

3. (20%) Given the system

$$\frac{dx(t)}{dt} = Ax(t) + Bu(t), \quad y(t) = Cx(t)$$

where $A=\begin{bmatrix}-1 & 0 & 0\\ 0 & -2 & 1\\ 0 & 0 & -2\end{bmatrix}$, $B=\begin{bmatrix}0\\ 1\\ 0\end{bmatrix}$, $C=\begin{bmatrix}1 & 1 & 1\end{bmatrix}$

(a) Find the state-transition matrix $\phi(t)$.

(b) Transform the state equations into the observability canonical form (OCF) and find the transformation matrix Q where $x(t)=Q\bar{x}(t)$.

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試 題

[第 2 節]

科目名稱	電子學
系所組別	電機工程學系- 電磁晶片組 計算機工程組 晶片系統組

－作答注意事項－

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國立中正大學 111 學年度碩士班招生考試試題

科目名稱：電子學　　本科目共 2 頁　第 1 頁

系所組別：電機工程學系-電磁晶片組、計算機工程組、晶片系統組

1. Fig. P1 shows a two-stage OP AMP with all transistors using the following parameters: $\mu_n C_{ox} = 2\mu_p C_{ox} = 200\ \mu A/V^2$, $V_{tn} = -V_{tp} = 0.6$ V, $|V_A| = 20$ V, $(W/L)_{M1, M2, M5, M6, M7} = 6.25$, and $(W/L)_{M3, M4, M8} = 12.5$. (Note: Transistors M_1, M_2, and M_7 are matched; M_3 and M_4 are matched; and M_5 and M_6 are matched. $V_{GSi|i=1\text{-}8}$, , $r_{oi|i=1\text{-}8}$ and $g_{mi|i=1\text{-}8}$ stand for dc voltages of gate-source voltage, output resistance, and transconductance of $M_{i|i=1\text{-}8}$, respectively.)
   (a) Assume that two inputs are grounded and channel length modulation effects are ignored, please calculate V_{GS1}, V_{GS3}, V_{GS5}, and V_{GS8}. Then, please identify the input common mode range. (5%)
   (b) Please calculate the overall voltage gain (v_o/v_{id}), where $v_{id} = v_I^+ - v_I^-$. (8%)
   (c) Please show that the common mode gain (A_{cm}) of the current-mirror loaded differential amplifier is approximately equal to $-1/(2r_{o2} \times g_{m5})$. (12%)
   (d) Please calculate the CMRR of the current-mirror loaded differential amplifier. (5%)

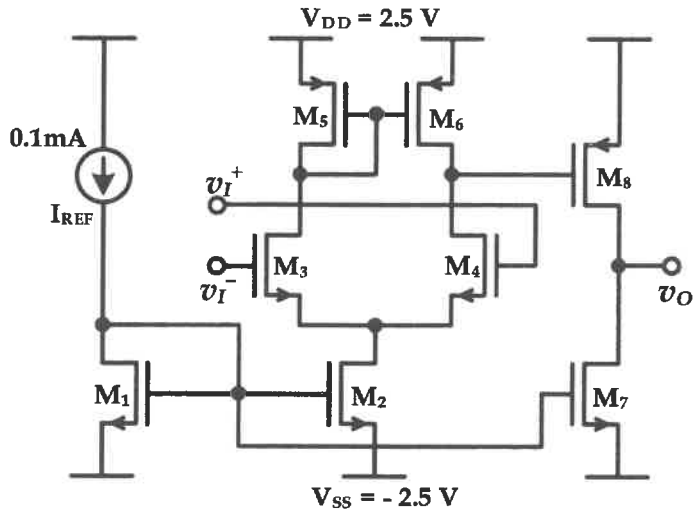

Fig. P1

2. Fig. P2 shows an amplifier circuit, in which the transistor M_1 has $g_m = 2$ mA/V, $r_o = 20$ KΩ, $C_{gs} = 40\ fF$, $C_{gd} = 10\ fF$, and $C_{db} = 10\ fF$. Please use open-circuit time constants method to find the upper-3-dB frequency (f_H), also determine the unity-gain frequency. (12%)

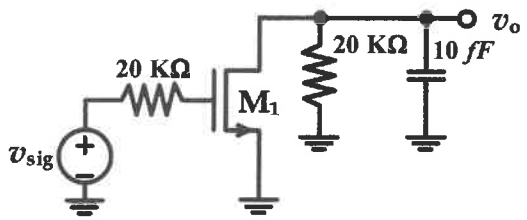

Fig. P2

3. Please implement the CMOS realization of the logic function: $Y = (A \cdot B + C \cdot D) \cdot E$. (8%)

4. For a silicon-based *pn* diode with cross-sectional area 10^{-4} cm^2, the doping of p-side and n-side are $5\times10^{17}/cm^3$ and $5\times10^{16}/cm^3$, respectively. The intrinsic carrier concentration (n_i), the thermal voltage (V_T) and the dielectric constant at 300K are 1.5×10^{10} cm^{-3}, 25.9 mV and 1.05×10^{-10} F/m, respectively
   (a) To determine the carrier concentrations (p_p, n_p, n_n, p_n) on the both sides of pn diode.? (5%)
   (b) What's the built-in potential (V_0) over the junction. (5%)

5. Fig. P5 is a feedback transconductance amplifier. All the MOS transistors are operated at $|V_{ov}|$=0.2V and with $|V_t|$=0.5V and $|V_A|$=20V. The values of resistors R_S and R_F are 10 kΩ.
   (a) If the M_1 gate is at zero dc voltage. Under negative feedback, what will be the gate voltage at M_2? (5%)
   (b) Please approximate the β value of feedback network. (5%)
   (c) Please determine the open-loop gain A. (5%)
   (d) Find the value of R_{out}. (5%)

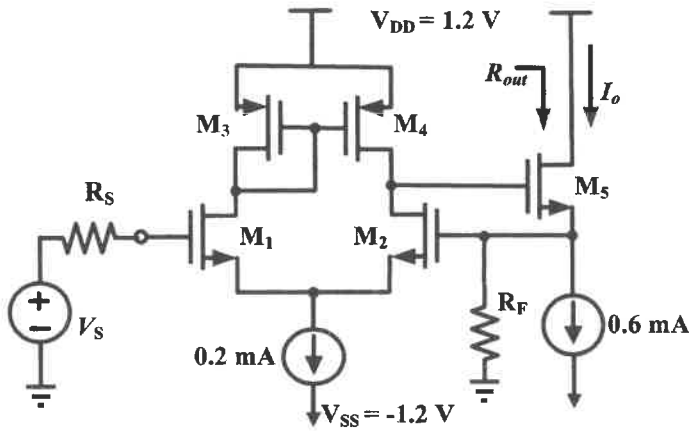

Fig. P5

6. Fig. P6 is a common-gate amplifier with current-mirror biased, all of the transistors are with k_n= k_p=5 mA/V^2, $|V_A|$= 30 V, and |Vt|= 0.8 V. R_S is 50 Ω and v_{sig} just only plays as ac signal without dc component.
   (a) Estimating r_o for all transistors.? (5%)
   (b) What's the transconductance of M_1 with a prediction of over-drive voltage V_{OV1}? (5%)
   (c) Finding the values of R_{in}? (5%)
   (d) Finding the values of R_{out}? (5%)

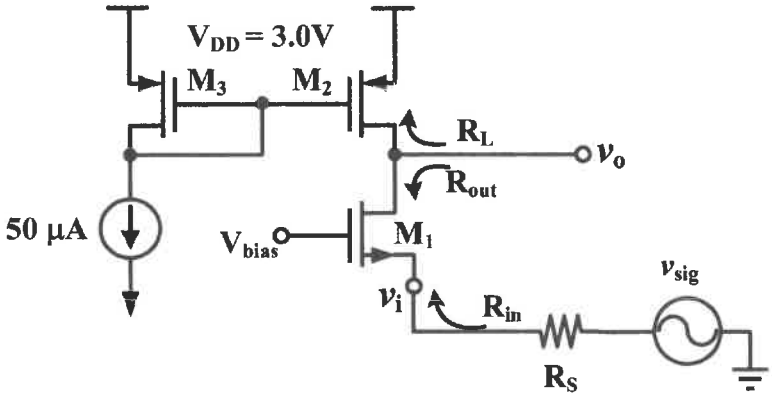

Fig. P6

國立中正大學
111 學年度碩士班招生考試
試 題

[第 2 節]

科目名稱	線性代數與微分方程
系所組別	電機工程學系－電磁晶片組 計算機工程組 電力與電能處理甲組

－作答注意事項－

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

1. 預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
2. 考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
3. 入場後於考試開始 40 分鐘內不得離場。
4. 全部答題均須在試卷（答案卷）作答區內完成。
5. 試卷作答限用藍色或黑色筆（含鉛筆）書寫。
6. 試題須隨試卷繳還。

Differential Equations

1. (10%) Find the Frobenius series solutions of the differential equation:

$$2x^2y'' + 3xy' - (x^2+1)y = 0$$

2. (10%) Use the *Laplace transform* to solve the integral equation

$$f(t) = \cos t + \int_0^t e^{-\tau} f(t-\tau)d\tau$$

3. (10%) Find a general solution of

$$\mathbf{y}' = \begin{pmatrix} 1 & 2 \\ 2 & 1 \end{pmatrix} \mathbf{y} + \begin{pmatrix} e^{2t} \\ -2t \end{pmatrix}, -\infty < t < \infty$$

4. (10%) Solve the initial value problem

$$y'' + 4\pi^2 y = 2\pi\delta(t-2), \quad y(0) = 0,\ y'(0) = 0.$$

5. (10%) **Matrix Exponent**
Use the Laplace transform to compute $e^{\mathtt{A}t}$ for

$$\mathtt{A} = \begin{pmatrix} 3 & 4 \\ 0 & 3 \end{pmatrix}$$

(Continue)

Linear Algebra

6. Let $\boldsymbol{A} = \begin{bmatrix} 1 & 1 & 1 & -1 \\ 0 & 2 & 0 & 0 \\ 0 & 1 & 3 & 0 \\ 0 & 0 & 0 & 4 \end{bmatrix}$. Find the results with details.

a. (10 %) The eigenvalues and their corresponding eigenvectors.

b. (10 %) Find a matrix $\boldsymbol{P}$ that diagonalizes $\boldsymbol{A}$.

c. (5 %) Find $\boldsymbol{A}^7$.

7. (25 %) Prove that a singular matrix with size $n \times n$ cannot be reduced as $\boldsymbol{I}_n$ by Gauss-Jordan elimination. (Hint: You can use the skill of contradiction to prove this rule)

If you have no idea about this proof, please show a 3×3 matrix without zero row and column as an example to explain this rule.

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試 題

[第 2 節]

科目名稱	資料結構
系所組別	電機工程學系-計算機工程組

—作答注意事項—

※作答前請先核對「試題」、「試卷」與「准考證」之系所組別、科目名稱是否相符。

1. 預備鈴響時即可入場，但至考試開始鈴響前，不得翻閱試題，並不得書寫、畫記、作答。
2. 考試開始鈴響時，即可開始作答；考試結束鈴響畢，應即停止作答。
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5. 試卷作答限用藍色或黑色筆（含鉛筆）書寫。
6. 試題須隨試卷繳還。

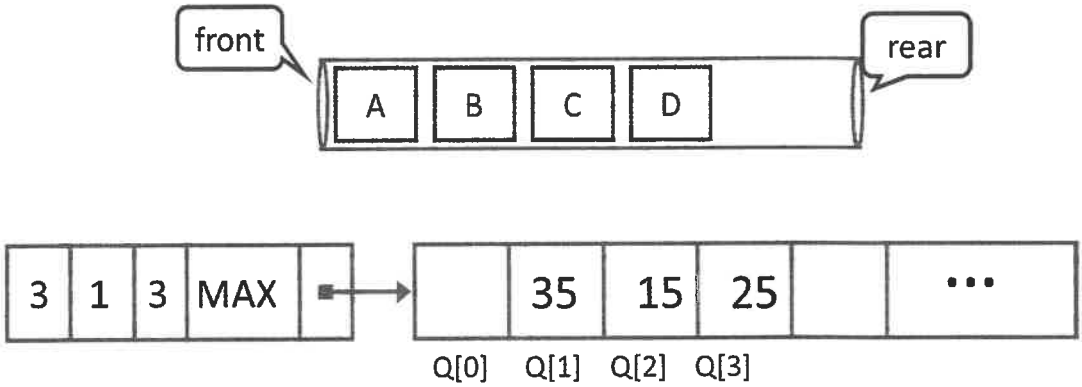
國立中正大學 111 學年度碩士班招生考試試題

科目名稱：資料結構　　本科目共 1 頁　第 1 頁

系所組別：電機工程學系-計算機工程組

1. Queues

Consider the following concept of a queue where the elements, A, B, C, and D, are integers. An example of design using an array is given below. The head of the queue contains five fields, the element count, the index to the front, the index to the rear, the maximum size of the array storage, and the pointer to the array storage. Answer the following by writing C code or pseudo code.



i. (5 points) Define the data structures to the queue head and the queue storage shown above.

ii. (20 points) Define the Enqueue function and the Dequeue function as regular FIFO (First In, First Out) manner.

iii. (10 points) Re-design your queue operations to make the above a priority queue in which the larger value comes out first.

2. Sorting

i. (15 points) Define the function to perform the **Heap Sort** on an integer array. The sorted array will be in ascending order. Be sure to define the function name, parameter list, return value, local variables, and calling method. Use C or pseudo code to complete your answer.

ii. (15 points) Analyze the time complexity of the function above and show the result in the Big-O notation. Be sure to show the steps in analysis and the associated calculation in detail.

3. Application

Consider a file containing 2 integers. There are two lines in the file, and each line contains just one integer with an unknown number of digits. Your task is to read those two integers, add two integers, and print the result. Answer the following by writing C code or pseudo code. For example, adding 11111111112222222222333333333344444444444 and 55555555556666666666777777777 will result 111111111177777777780000000000222222221.

i. (5 points) Design your data structure to store the integers. *Note: unknown number of digits.*

ii. (15 points) Using the data structure above, write the function to read two integers from the input file.

iii. (15 points) Write the function to add such two integers and print the result.