國立中山大學109學年度
碩士暨碩士專班招生考試試題

科目名稱：電子學【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109學年度碩士暨碩士專班招生考試試題

科目名稱：電子學【電機系碩士班甲組】　　題號：431009

※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

Please note that all calculation answers must include the unit and calculation process.

1. (40pt) The NMOS transistor in the CS amplifier shown in Fig. 1 has $V_t = 0.7$ V, $V_A = 50$ V, $R_{sig} = 120$ kΩ, $R_{G1} = 300$ kΩ, $R_{G2} = 200$ kΩ, $R_D = 5$ kΩ, $R_S = 2$ kΩ, $R_L = 5$ kΩ, and $V_{DD} = 5$ V. (a) Neglecting the channel length modulation effect, the MOSFET is operating in saturation with $I_D = 0.5$ mA and $V_{OV} = 0.3$ V. What must the MOSFET's $\mu_n C_{ox}(W/L)$ be? What is the dc voltage at the drain? (b) Find the input resistance R_{in} and overall gain v_o/v_{sig} (V_A effect needs to be considered). (c) If v_{sig} is a sinusoid with a peak amplitude v_s, find the maximum allowable value of v_s for which the transistor remains in saturation. What is the corresponding amplitude of the output voltage? (d) What is the value of resistance R_3 that needs to be inserted in series with capacitor C_{C3} as shown in Fig. 2 in order to allow us to double the input signal peak amplitude v_s? What output voltage now results? (10pt*4)
2. (20pt) For the follower circuit in Fig. 3, let transistor Q_1 has $\beta = 50$ and transistor Q_2 has $\beta = 100$, $V_{CC} = 5$ V, $R_{B1} = R_{B2} = 1$ MΩ, $I_1 = 50$ μA, $I_2 = 5$ mA and neglect the Early effect. Use constant voltage drop model of $V_{BE} = 0.7$ V. Thermal voltage $V_T = 25$ mV. (a) Find the dc emitter current and the dc base voltage of Q_1 transistor. (b) If a load resistance $R_L = 1$ kΩ is connected to the output terminal, find the voltage gain from the base to the emitter of Q_2 and the input resistance R_{ib2} looking into the base of Q_2. (10pt*2)
3. (15pt) A current-mirror-loaded MOS differential amplifier of the type shown in Fig. 4 is specified as follows: $(W/L)_n = 100$, $(W/L)_p = 200$, $\mu_n C_{ox} = 2\ \mu_p C_{ox} = 0.2$ mA/V^2, $V_{An} = |V_{Ap}| = 20$ V, and $I = 0.8$ mA. (a) Calculate the differential gain A_d. (b) Let the output resistance of current source is 25 kΩ. Calculate common-mode gain $|A_{cm}|$ and CMRR (in dB). (5pt, 10pt)
4. (25pt) Consider a CC-CE amplifier such as that in Fig. 5 with the following specifications: $I_1 = I_2 = 1$ mA and identical transistors with $\beta = 100$, $f_T = 400$ MHz, and $C_\pi = 2$ pF. Thermal voltage $V_T = 25$ mV. Let the amplifier be fed with a source v_{sig} having a resistance $R_{sig} = 4$ kΩ, and assume a load resistance $R_L = 4$ kΩ. Find the midband voltage gain v_o/v_{sig} and estimate the 3-db frequency f_H by the method of open-circuit time constants (please show the value of each time constant). (5pt, 20pt)

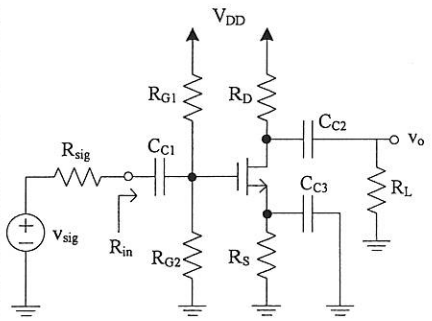

Fig. 1

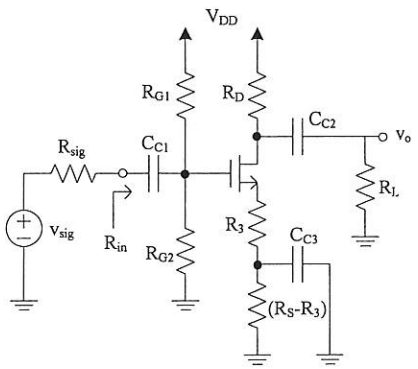

Fig. 2

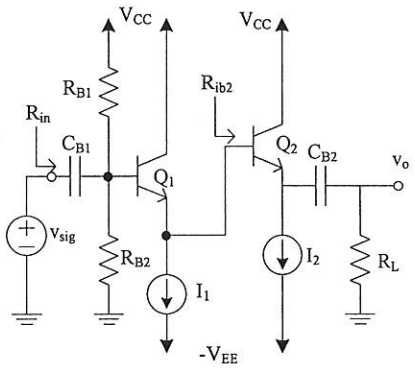

Fig. 3

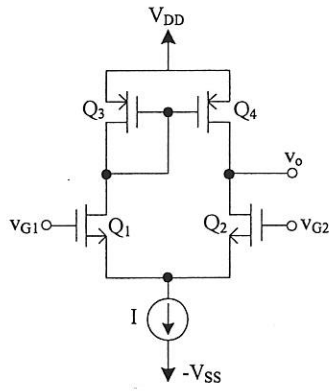

Fig. 4

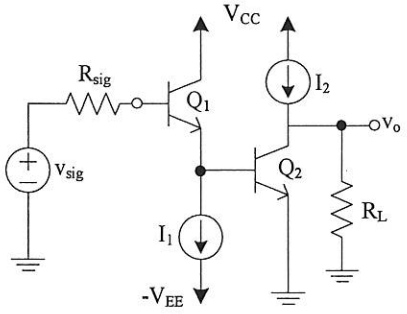

Fig. 5

試題請隨卷繳回，請留意背面是否有題

國立中山大學109學年度
碩士暨碩士專班招生考試試題

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

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國立中山大學109學年度碩士暨碩士專班招生考試試題

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）　　

1.(20%) Given a system described by the following differential equation

$$\frac{d^2y(t)}{dt^2}+5\frac{dy(t)}{dt}+6y(t)=\frac{du(t-1)}{dt},$$

where u is the input and y is the output.

(a)(10%) Find the transfer function of the system.

(b)(10%) Is the system of minimum phase, and why?

2.(20%) Design a feedback controller to regulate the output of the plant

$$P(s)=\frac{10}{0.1s+1}$$

to any prescribed constant level without any steady-state error, and make the resulting closed-loop poles at $s=-70,\ -100$.

3.(10%) Given a controller $C(s)=(s-1)/(s+1)$ and a plant $P(s)=s/\left[(s-1)(s+2)\right]$ in negative feedback, determine the stability of the feedback system.

4.(18%) Given a characteristic equation of a control system as

$$s^2(s^2+8s+24)+(32+k)s+6k=0.$$

Find the

(a)(2%) open loop pole(s) and zero(s);

(b)(3%) intersection of the asymptotes (Centroid);

(c)(3%) angles of asymptotes;

(d)(4%) intersection of the Root Loci with the imaginary axis and the value of k, then

(e)(6%) construct the Root Loci for $-\infty \le k \le \infty$.

5.(32%) Consider a control system with the following loop transfer function

$$L(s)=\frac{K(s+1)}{s(s-1)},\qquad -\infty \le K \le \infty$$

(a)(18%) A Nyquist path is shown in Fig. 1.

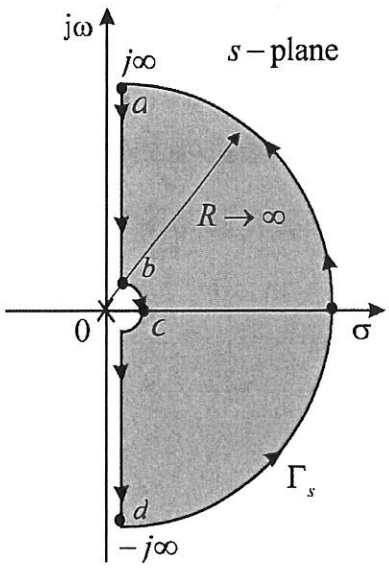

Figure 1: A Nyquist path.

Sketch the Nyquist plot of this system for $K > 0$ in accordance with fig. 1, and indicate clearly I. the intersection(s) of the Nyquist plot with real and imaginary axes if any II. each mapping of point $a:(0+j\omega, \omega \to \infty^+)$, $b:(0+j\omega, \omega \to 0^+)$, $c:(\epsilon e^{j\phi}, \epsilon \to 0,\ \phi \to 0^+)$ and $d:(0-j\omega, \omega \to \infty^+)$ in your plot.

(b)(8%) Suppose that the Nyquist plot ($K > 0$) you obtained in part (a) is depicted in Fig. 2, where the solid line is part of the Nyquist plot when ω is from ∞^+ to 0^+, and it has an intersection with axis $-Re(L(s))$ at $-K$.

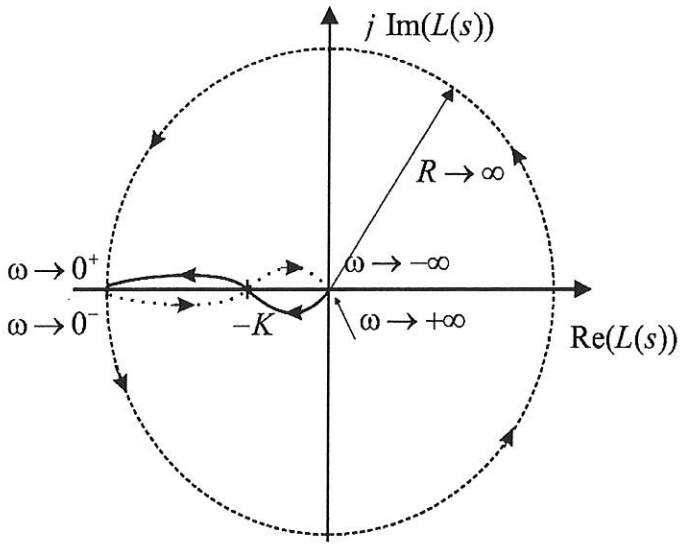

Figure 2: Your answer in part (a) (Assumption).

Using Nyquist criterion, determine the range of $K > 0$ such that the closed-loop system can be stabilized. If the system is unstable due to the range of K, find the number of closed-loop pole(s) in the right-half of s-plane.

(c)(6%) Using Nyquist criterion and Fig. 2, determine the range of $K < 0$ such that the closed-loop system can be stabilized. If the system is unstable due to the range of K, find the number of closed-loop pole(s) in the right-half of s-plane.

國立中山大學109學年度
碩士暨碩士專班招生考試試題

科目名稱：離散數學【電機系碩士班丙組】

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國立中山大學109學年度碩士暨碩士專班招生考試試題

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）　　

Problem 1. (20points) TRUE or FALSE: Decide whether or not the following statements are True(O) or False(X). You do **not** have to justify the answer. Each correct answer is 5 points, and each incorrect one is -3 points (until you get 0 points in problem 1). If you choose not to answer, you get 0 points for each.

1.1 True(O) or False(X): Assume that A and B are problems. If A is an NP one and B is in P, $A \cap B$ is not NP-complete.

1.2 True(O) or False(X): If A is in NP-complete and A can be solved in polynomial time less than B, B belongs to NP-complete.

1.3 True(O) or False(X): Solutions to the class of NP problems can be verified in polynomial time.

1.4 True(O) or False(X): A class of NP problems without known polynomial algorithms that can be reduced to one another is called NP-complete.

Problem 2. (15 points) Decide the complexity of the following computation. Please justify your answer. Otherwise, you get 0 points.

If N and M are positive integers, then the complexity $1^M + 2^M + \ldots + N^M = O(L)$. What is L in terms of N and M?

Problem 3. (35 points). Find and draw all the spanning trees of the following graphs. You have to list all the spanning trees to get full points for each subproblem. Otherwise, you get 0 points.

3.1 K3 (i.e., a complete graph with 3 vertices). **(5 points)**

3.2 K2,2 (i.e., a complete bipartite graph with 4 vertices). **(15 points)**

3.3 Find the total number of spanning trees of the graph. **(15 points)**

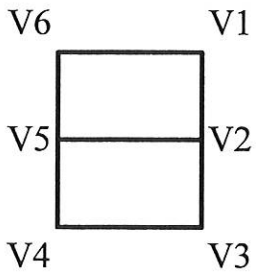

Fig. 1

Problem 4. (20 points). Use Dijkstra's algorithm to find the shortest path between V1 and V7. Please justify your answer. Otherwise, you get 0 points.

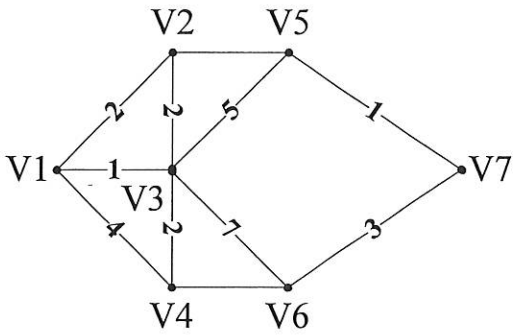

Fig. 2

Problem 5. (10 points). There are 12 students, and you are a coach. You want to divide the students into three specific groups, i.e.,G1, G2, and G3, so that each group contains four students. Please decide how many ways you can divide them. Please justify your answer.

國立中山大學109學年度
碩士暨碩士專班招生考試試題

科目名稱：電路學【電機系碩士班丁組】

—作答注意事項—

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國立中山大學109學年度碩士暨碩士專班招生考試試題

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）　　

1. (10pt) A Lithium Ion battery module is rated at 12V/6Ah. Two battery modules in series connection are discharged by 1C constant current for 30 minutes. Determine the total energy supplied by batteries.

2. (10pt) The voltage across a load and the current through it are given by $v(t)=10+30\cos(100t)$ V and $i(t)=1-2\sin(100t)$ A, respectively. Find:
   (1) RMS value of the current. (5pt)
   (2) Average power consumption. (5pt)

3. (10pt) A three-phase transmission line has an impedance of $4+2j\Omega$ per phase. It supplies a load of 1MVA at 0.75 power factor lagging. If load voltage is 4200V, find power loss in the transmission line and source voltage.

4. (10pt) Determine average dc output voltage of a single-phase full-wave rectifier applied by 110V RMS ac voltage.

5. (10pt)A buck converter is operated with the following parameters: Vg=20V, Vo=10V, L=50uH, switching frequency 10kHz, output power 20W.
   (1) Draw the waveform of inductor current.(5pt)
   (2) Draw the waveform of diode voltage. (5pt)

6. (10pt)A four-pole, 60Hz induction motor supplies 15kW to a load at 5% slip. Determine :
   (1) Rotor speed.(5pt)
   (2) Rotor frequency.(5pt)

7. (20pt) Determine the center frequency and bandwidth of the bandpass filter in the figure 1.

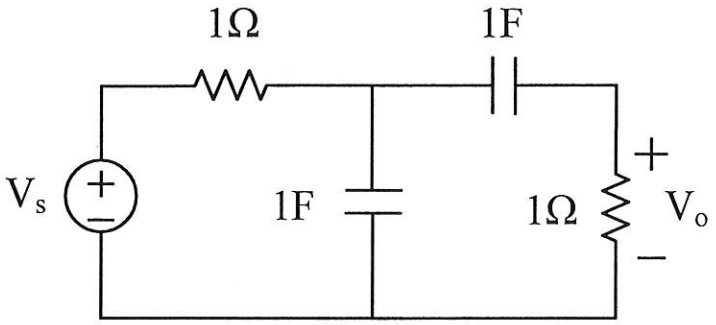

Figure 1

8. (20pt) For the s-domain circuit in figure 2, determine the transfer function and $v_o(t)$ if $v_s(t)=\sin 2t$.

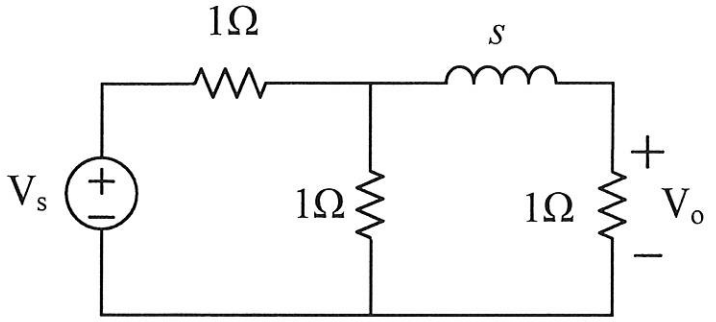

Figure 2

試題請隨卷繳回，請留意背面是否有題

國立中山大學109學年度
碩士暨碩士專班招生考試試題

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

- **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，不得另攜帶紙張，請衡酌作答。
- 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，其後果由考生自行負擔。
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- 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109學年度碩士暨碩士專班招生考試試題

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）（選擇題）　　

Note: There are 5 question sets, each containing 5 questions in it. Each question deserves 4 points. In each question set, the first 3 questions have one answer while the last two may have multiple answers. One quarter of points will be deducted for single-choice questions, and no deduction for multiple-choices questions.

請注意：此份考卷共有五個題組，每題組包含五題，每題 4 分。每題組的前三題是單選題，後兩題是複選題。單選題答錯倒扣 1/4，複選題答錯不倒扣。

Question set I

Suppose we have the following function:

```
kkk(A,i,n) {
    if (n>1) {
        Exchange the values of A[i] and A[i+n-1];
        kkk(A,i+1,n-2);
    }
}
```

Note that A is an integer array starting with index 0. Each integer occupies 4 bytes in the byte-addressable memory. Please answer the following questions.

1. If the address of A[2] is $00EC_{16}$, what is the address of A[5]? (a) $00EF_{16}$; (b) $00EC_{16}$; (c) $00F8_{16}$; (d) $00FF_{16}$.
2. How many times kkk will be called in the function body of kkk(A,0,4)? (a) 1; (b) 2; (c) 3; (d) 4.
3. What is the time complexity of this function? (a) O(n); (b) $O(\log_2 n)$; (c) $O(n^2)$; (d) $O(n^3)$.
4. Let A=[20,80,30,40,10,70,50]. After executing kkk(A,0,7), which of the following are true? (a) A[0]=70; (b) A[2]=10; (c) A[4]=50]; (d) A[6]=20.
5. Let A=[15,25,35,45,55,65,75,85]. After executing kkk(A,0,8), which of the following are true? (a) A[1]=75; (b) A[3]=55; (c) A[5]=35; (d) A[7]=65.

Question set II

Suppose we have a stack for storing integers. Initially, the stack is empty. We perform 10 operations push(1), push(2), pop(), push(3), pop(), pop(), push(4), push(5), push(6), and pop(). Please answer the following questions.

6. We use an array A of 10 elements to implement the stack. Which one is true for declaring the array in C? (a) integer A:10; (b) integer A[0,9]; (c) integer A[1,10]; (d) integer A[10].
7. We use the array A as defined above to implement the stack. We want to store the first integer at index=0. Let the latest input be stored at index=top. What is the value of top for the empty stack? (a) top=0; (b) top=1; (c) top=-1; (d) top=9.
8. We use the linked-based implementation for the stack. Let the latest input be stored at the location with address in first. What is the value of first for the empty stack? (a) first=-1; (b) first=0; (c) first=1; (d) first=2.
9. We use the array A as defined above to implement the stack. After executing the 10 operations in sequence, which of the following are true? (a) top=1; (b) A[0]=4; (c) A[1]=5; (d) The stack has 3 integers.
10. We use the linked-based implementation as defined above for the stack. After executing the 10 operations, which of the following are true? (a) first is not 0; (b) first contains the address where 5 is stored; (c) A[first]=4; (d) A -> first = 4.

Question set III

Suppose we have an array A containing 9 integers (with the first index being 0):

240, 119, 682, 341, 225, 556, 122, 661, 245

Please answer the following questions.

11. We use Bubble Sort to sort the array in ascending order. What is A[8] after the first pass? (a) 661; (b) 556; (c) 682; (d) 245.
12. We use Bubble Sort to sort the array in ascending order. What is A[7] after the second pass? (a) 122; (b) 661; (c) 556; (d) 225.
13. We use Quick Sort to sort the array in ascending order. For each partition, let the rightmost element be the pivot. Which one stores 245 after the first partition? (a) A[3]; (b) A[7]; (c) A[5]; (d) A[4].
14. We use Quick Sort to sort the array in ascending order. Which of the following are false after the first partition? (a) A[0]=240; (b) A[8]=682; (c) A[3]=341; (d) A[7]=661.
15. We use Heap Sort to sort the array in ascending order. But first, we have to convert the array into a maxheap. Which of the following are true in the resulting maxheap? (a) A[0]=682; (b) A[3]=341; (c) A[5]=240; (d) A[8]=245.

Question set IV

Let the height of a tree be the number of nodes along the longest path from the root node to the leaf nodes. Suppose we have 10 integers 35, 46, 30, 34, 99, 42, 75, 28, 70, 80. Please answer the following questions.

16. We create binary trees for these integers. What is the minimum height of all the possible trees? (a) 1; (b) 2; (c) 3; (d) 4.
17. We create binary trees for these integers. What is the maximum height of all the possible trees? (a) 10; (b) 9; (c) 8; (d) 7.
18. We create an AVL tree by considering the integers one by one, starting with the first one, 30. Which of the following is true? (a) The height of the resulting tree is 5; (b) The root of the resulting tree is 75; (c) The node for 46 has one child; (d) The parent of 99 is the node for 75.
19. We create a binary search tree by considering the integers one by one, starting with the first one, 30. Which of the following are true? (a) The node for 75 is a leaf node; (b) The node for 42 is an internal node; (c) The node for 99 has only one child; (d) The height of the resulting tree is 5.
20. Based on the binary search tree obtained in Question 19, we delete 99 from the tree. Which of the following are true? (a) The parent of 75 is the node for 46; (b) The node for 30 has two children; (c) The node for 70 is an internal node; (d) The height of the resulting tree is 4.

Question set V

Suppose we have an undirected graph G=(V,E), where V={a,b,c,d,e,f,g,i} and E={[(a,i), 2], [(a,b), 6], [(a,g), 4], [(b,c), 7], [(b,e), 9], [(c,d), 4], [(d,g), 5], [(e,g), 8], [(f,g), 2], [(f,i), 3]}. Note that [(x,y),w] indicates that there is an edge, with weight w, between vertices x and y. Please answer the following questions.

21. We find a spanning tree for the graph using the depth-first search algorithm, starting with vertex e. Note that if two or more vertices qualify, then the one with the least alphabetical order is selected. What is the sum of the weights involved in the resulting tree? (a) 31; (b) 32; (c) 33; (d) 34.
22. We find a spanning tree for the graph using the breadth-first search algorithm, starting with vertex e. Note that if two or more vertices qualify, then the one with the least alphabetical order is selected. What is the sum of the weights involved in the resulting tree? (a) 40; (b) 39; (c) 38; (d) 37.
23. We find a spanning tree for the graph using the Prim's algorithm, starting with vertex e. Note that if two or more vertices qualify, then the one with the least alphabetical order is selected. What is the sum of the weights involved in the resulting tree? (a) 30; (b) 29; (c) 28; (d) 27.

24. Which of the following are true for the resulting tree obtained in Question 21? (a) The node following node a is node g; (b) The edge (e,g) is contained in the tree; (c) The edge (c,d) is contained in the tree; (d) The edge (b,c) is contained in the tree.
25. Which of the following are true for the resulting tree obtained in Question 23? (a) The edge (a,g) is contained in the tree; (b) The edge (a,b) is contained in the tree; (c) The edge (b,c) is contained in the tree; (d) The edge (c,d) is contained in the tree.

國立中山大學109學年度
碩士暨碩士專班招生考試試題

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

- **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，不得另攜帶紙張，請衡酌作答。
- 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，其後果由考生自行負擔。
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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109學年度碩士暨碩士專班招生考試試題

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）　　

1. What range of impurity gradient should be considered if we want to obtain the breakdown voltage V_B = 250 to 750 V in a linearly graded Si *p-n* junction? Assume the breakdown maximum electric field $E_m = 2.5 \times 10^5$ V/cm, $\varepsilon_r = 11.9$. (20%)

2. Copper is deposited on an *n*-type Si substrate to form an ideal Schottky diode. $q\phi_m = 4.65$ eV, the electron affinity is 4.01 eV, $N_D = 5 \times 10^{16}$ cm^{-3}. Calculate the barrier height, the built-in potential, the depletion-layer width, and the maximum field at zero bias. T = 300K. Effective density of states in conduction band is 2.86×10^{19} cm^{-3}. (20%)

3. Derive the depletion layer width of a *p-n* junction. Doping concentrations are N_A and N_D. Dielectric constant is ε_s and the built-in potential is V_{bi}. (20%)

4. Calculate the emitter injection efficiency. Assume the following transistor parameters:
   Doping concentrations in base and emitter are $N_B = 3 \times 10^{15}$ cm^{-3} and $N_E = 2 \times 10^{17}$ cm^{-3}. Widths of neutral base and emitter are $x_B = 0.8$ μm and $x_E = 0.5$ μm.
   Minority carrier diffusion coefficients in base and emitter are $D_B = 20$ cm^2/s and $D_E = 10$ cm^2/s. (20%)

5. Calculate the threshold voltage shift due to short-channel effect. Consider an *n*-channel MOSFET with $N_A = 5 \times 10^{16}$ cm^{-3}, channel length L = 1 μm, diffused junction depth $r_j = 0.3$ μm, oxide thickness $t_{ox} = 200$Å , and dielectric constant of oxide is 3.9. (20%)

國立中山大學109學年度
碩士暨碩士專班招生考試試題

科目名稱：工程數學乙【電機系碩士班乙組】

－作答注意事項－

考試時間：100分鐘

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國立中山大學109學年度碩士暨碩士專班招生考試試題

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）(混合題)　　

下面 1-10 題為是非題，總分 20 分。每題答對 2 分，答錯扣 3 分，未作答者以 0 分計。總分低於 0 分者以 0 分計。

1. 微分方程式 $\dddot{y}(t)+3t^2\dot{y}(t)+|t|y(t)=0$ 為非線性方程式。
   (A) 是 (B) 否
2. 微分方程式 $\ddot{x}(t)+(1+x(t)^2)\dot{x}(t)+(1-x(t)^2)x(t)=0$ 有三個平衡點。
   (A) 是 (B) 否
3. 微分方程式 $\ddot{y}(t)+3\dot{y}(t)-y(t)=0$ 的解，不管初值為何，都會收斂到 0。
   (A) 是 (B) 否
4. 微分方程式 $\dot{y}(t)+t^2y(t)^3=0$ 的解，在初值 $y(0)<0$ 的情況下，滿足 $\lim_{t\to\infty}|y(t)|=\infty$。
   (A) 是 (B) 否
5. 微分方程式 $\ddot{y}(t)+y(t)=u(t)$ 的解，在 $|u(t)|$ 之值有上界的情況下，有可能會發散。
   (A) 是 (B) 否
6. 微分方程式 $\ddot{y}(t)+\dot{y}(t)+y(t)=\sin\omega t$ 的穩態解，在 $\omega=1$ 時有最大振幅。
   (A) 是 (B) 否
7. 拉普拉斯轉換（Laplace transform）為線性轉換。
   (A) 是 (B) 否
8. 令函數 $y(t)$ 的拉普拉斯轉換為 $Y(s)$。則 函數 $\ddot{y}(t)$ 的拉普拉斯轉換為 $s^2Y(s)$。
   (A) 是 (B) 否
9. 令函數 $y(t)$ 的拉普拉斯轉換為 $Y(s)$。則 函數 $\mathrm{e}^{-t}y(t)$ 的拉普拉斯轉換為 $Y(s+1)$。
   (A) 是 (B) 否
10. 函數 $f(t)=\mathrm{e}^{-t}\sin t,\ t\in[0,\infty)$ 的傅立葉轉換（Fourier transform）為 $\frac{1}{(1-\omega^2)(1+j\omega)}$。
    (A) 是 (B) 否

下面 11-15 題為單選題，每題 4 分，答錯或未作答者該題以 0 分計。11-15 題總共 20 分。

考慮微分方程式 $\ddot{z}(t)+b\dot{z}(t)+\sin(z(t))=u(t)$ ，並回答以下第 11 至 15 題。

11. 假設 $u(t)\equiv 0,\ \forall t$。下列哪一組初值 $(\dot{z}(0),z(0))$ 所對應的解不是 $z(t)\equiv 0,\ \forall t$。
    (A) $(0,0)$ (B) $(\pi,0)$ (C) $(0,\pi)$ (D) $(0,-\pi)$
12. 假設 $u(t)\equiv 0,\ \forall t$。將前述方程式就 $(\dot{z}(0),z(0))=(0,0)$ 線性化後之線性方程式，滿足以下哪個敘述?
    (A) 若 $b=0$ ，則任何初值對應的解皆會收斂到 0。
    (B) 若 $b=0$ ，則有些初值對應的解皆會發散。
    (C) 若 $b=1$ ，則任何初值對應的解皆會收斂到 0。
    (D) 若 $b=-1$ ，則有些初值對應的解皆會收斂到 0。

13. 假設 $u(t) \equiv 0,\ \forall t$。將前述方程式就 $(\dot{z}(0), z(0)) = (0, \pi)$ 線性化後之線性方程式，滿足以下哪個敘述?

(A) 若 $b = 0$，則有些初值對應的解皆會收斂到 0。
(B) 若 $b = 0$，則任何初值對應的解皆會收斂到 0。
(C) 若 $b = 1$，則任何初值對應的解皆會收斂到 0。
(D) 若 $b = 1$，則任何初值對應的解皆會發散。

14. 考慮將前述方程式就 $(\dot{z}(0), z(0)) = (0, 0)$ 線性化後之線性方程式。假設 $b = 0$，且該方程式之輸入項（forcing term）為單位步階函數。下列敘述何者為正確?

(A) 該線性方程式的解會收斂到 1。
(B) 如該線性方程式的初值為 $(1, 0)$，則方程式的解為 $\sin t$。
(C) 該線性方程式的解會發散
(D) 該線性方程式的解會不斷震盪。

15. 考慮將前述方程式就 $(\dot{z}(0), z(0)) = (0, 0)$ 線性化後之線性方程式。假設 $b = 2$，且該方程式之輸入項（forcing term）為 $\sin t$。下列敘述何者為正確?

(A) 該線性方程式的解會收斂到 $-\frac{1}{2}\cos t$。
(B) 該線性方程式的解會收斂到 $\sin t$。
(C) 如該線性方程式的初值為 $(0, 0)$，則方程式的解為 $\sin t$。
(D) 如該線性方程式的初值為 $(0, 1)$，則方程式的解為 $\cos t$。

下面 16-23 題為複選題，每題 5 分，總分 40 分，每錯一個選項扣 2 分，得分低於零分或未作答者，該題以零分計。

16. 令 $\mathbf{A} = \begin{bmatrix} -1 & 1 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$。下列關於 $e^{\mathbf{A}t}$ 之敘述何者正確?

(A) 該矩陣是一個 3×3 的方陣。
(B) 該矩陣在 $t \geq 0$ 時，永為一個可逆矩陣。
(C) 該矩陣 $(3, 2)$ 位置那一項為 e^{t}。
(D) 該矩陣 $(1, 2)$ 位置那一項為 te^{-t}。
(E) 當 $t \to \infty$ 時，該矩陣收斂為 0 矩陣。

17. 考慮微分方程組 $\begin{bmatrix} \ddot{x}_1(t) \\ \ddot{x}_2(t) \end{bmatrix} = \begin{bmatrix} \alpha & 1 \\ 1 & \beta \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \end{bmatrix}$。下列敘述何者正確?

(A) 若$(\alpha, \beta) = (0, 0)$，則有些「非零初值」對應之解會發散。
(B) 若$(\alpha, \beta) = (0, 0)$，則任何「非零初值」對應之解都不會發散。
(C) 若$(\alpha, \beta) = (1, 1)$，則方程式之解是頻率為 $e^{\sqrt{2}t}$ 與 $e^{-\sqrt{2}t}$ 之線性組合。
(D) 若$(\alpha, \beta) = (1, 1)$，則方程式之解是頻率為 $\sin\sqrt{2}t$ 與 $\cos\sqrt{2}t$ 之線性組合。
(E) 若$(\alpha, \beta) = (-2, -2)$，則方程式之解是頻率為 1 與 $\sqrt{3}$ 之旋波的線性組合。

18. Consider the linear equation $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3, \mathbf{a}_4] \in \mathbb{R}^{3\times4}$ and $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3, \mathbf{a}_4$ are column vectors of $\mathbf{A}$. Suppose $\mathbf{a}_1 + \mathbf{a}_2 + \mathbf{a}_3 + \mathbf{a}_4 = \mathbf{b}$. Which of the following statements are true?
(A) The linear equation has exactly one solution.
(B) The linear equation has infinitely many solutions.
(C) No conclusion can be drawn about the number of solutions to the linear equation.
(D) The vectors $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3, \mathbf{a}_4$ are linearly dependent.
(E) $\text{rank}([\mathbf{A}, \mathbf{b}]) = \text{rank}(\mathbf{A})$

19. Consider the linear equation $\mathbf{Ax} = \mathbf{b}$ with $\mathbf{A} \in \mathbb{R}^{m\times n}$. Which of the following statements are true?
(A) If $\text{rank}(\mathbf{A}) = m$, then there exists at least one solution.
(B) If $\text{rank}(\mathbf{A}) = n$, then there exists exactly one solution.
(C) If $\text{rank}(\mathbf{A}) = n$, then the column vectors of $\mathbf{A}$ are linearly independent.
(D) If $n > m$, then there exists at least one solution.
(E) If $m > n$, then there exists at most one solution.

20. Consider the linear mapping $L: V \to W$. Let $\mathbf{0}_V$ and $\mathbf{0}_W$ be the zero vectors in V and W, respectively. Which of the following statements are true?
(A) The condition $L(\mathbf{v}_1) = L(\mathbf{v}_2)$ implies $\mathbf{v}_1 = \mathbf{v}_2$.
(B) For any $\mathbf{w} \in W$, there exists $\mathbf{v} \in V$ such that $L(\mathbf{v}) = \mathbf{w}$.
(C) If L is one-to-one, then $L(\mathbf{v}) = \mathbf{0}_W$ implies $\mathbf{v} = \mathbf{0}_V$.
(D) If $\mathbf{v}_1, \mathbf{v}_2, \cdots, \mathbf{v}_k$ are linearly independent, $L(\mathbf{v}_1), L(\mathbf{v}_2), \cdots, L(\mathbf{v}_k)$ are also linearly independent.
(E) The condition $c_1\mathbf{v}_1 + c_2\mathbf{v}_2 + \cdots + c_k\mathbf{v}_k = \mathbf{0}_V$ implies $c_1L(\mathbf{v}_1) + c_2L(\mathbf{v}_2) + \cdots + c_kL(\mathbf{v}_k) = \mathbf{0}_W$.

21. Given vectors $\mathbf{x}, \mathbf{y}, \mathbf{z}$ in $\mathbb{R}^n$ and matrices $\mathbf{A}, \mathbf{B}, \mathbf{C}$ in $\mathbb{R}^{n\times n}$. Which of the following statements are true?
(A) If $\mathbf{x}^T\mathbf{y} = 0$ and $\mathbf{y}^T\mathbf{z} = 0$, then $\mathbf{x}^T\mathbf{z} = 0$.
(B) $\text{rank}(\mathbf{x}^T\mathbf{y}) = \text{rank}(\mathbf{x}\mathbf{y}^T) = 1$
(C) $(\mathbf{A} + \mathbf{B})(\mathbf{A} - \mathbf{B}) = \mathbf{A}^2 - \mathbf{B}^2$
(D) If $\mathbf{AC} = \mathbf{BC}$ and $\mathbf{C}$ is not the zero matrix, then $\mathbf{A} = \mathbf{B}$.
(E) If $\mathbf{AB}$ equals the zero matrix, then $\mathbf{BA}$ also equals the zero matrix.

22. Let $\mathbf{A} \in \mathbb{R}^{m\times n}$, $\text{R}(\mathbf{A})$ denote the column space of $\mathbf{A}$, $\text{N}(\mathbf{A})$ denote the null space of $\mathbf{A}$, and $\dim(S)$ denote the dimension of a subspace S. Which of the following statements are true?
(A) For any $\mathbf{x} \in \mathbb{R}^n$, there exists $\mathbf{u} \in \text{R}(\mathbf{A}^T)$ and $\mathbf{v} \in \text{N}(\mathbf{A})$ such that $\mathbf{x} = \mathbf{u} + \mathbf{v}$.
(B) Suppose $\mathbf{u} \in \text{R}(\mathbf{A})$ and $\mathbf{v} \in \text{N}(\mathbf{A}^T)$. Then $\mathbf{u}^T\mathbf{v} = 0$.
(C) $\dim(\text{R}(\mathbf{A})) + \dim(\text{N}(\mathbf{A}^T)) = n$
(D) For any $\mathbf{y} \in \text{R}(\mathbf{A})$, there exists $\mathbf{x} \in \mathbb{R}^m$ such that $\mathbf{y} = \mathbf{A}\mathbf{A}^T\mathbf{x}$.
(E) If $\mathbf{y} \in \text{N}(\mathbf{A}^T) \cap \text{R}(\mathbf{A})$, then $\mathbf{y}$ is the zero vector in $\mathbb{R}^m$.

23. Let $\mathbf{A} \in \mathbb{R}^{n\times n}$ and $\mathbf{x} \in \mathbb{R}^n$. Which of the following statements are true?
(A) If $\mathbf{A}$ is singular, then 0 is an eigenvalue of $\mathbf{A}$.
(B) $\mathbf{A}$ and $\mathbf{A}^T$ share the same eigenvalues and eigenvectors.
(C) If $\mathbf{A}$ is diagonalizable, then $\mathbf{A}$ has n distinct eigenvalues.
(D) Suppose that $\mathbf{A}$ is nonsingular. The condition $\mathbf{Ax} = \lambda\mathbf{x}$ implies $\mathbf{A}^{-1}\mathbf{x} = \lambda^{-1}\mathbf{x}$.
(E) Suppose that all the eigenvalues of $\mathbf{A}$ are real and positive. Then we have $\det(\mathbf{A}) > 0$.

以下第24題到第25題需要簡明寫出計算過程，答案正確但沒有計算過程，將酌扣分數或不給分。

24. (12%) Let $x-\alpha$ be a vector in the vector space $C[0,1]$ with inner product $\langle f,g\rangle=\int_0^1 f(x)g(x)dx$.
   (a) (2%) Find α such that $x-\alpha$ is orthogonal to 1.
   (b) (4%) Let S be the subspace of all linear functions in $C[0,1]$. Find an orthonormal basis $\{u_1(x),u_2(x)\}$ for S.
   (c) (6%) Find the best least squares approximation to x^2 on the interval $[0,1]$ by a linear function.

25. (8%) Suppose $\mathbf{x}(\mathrm{k})=\mathbf{A}^{\mathrm{k}}\mathbf{x}(0)$ where k is an integer ranging from 1 to $+\infty$, and

$$\mathbf{A}=\begin{bmatrix}1 & 0 & 0\\ -2 & 1 & 3\\ 1 & 1 & -1\end{bmatrix},\ \mathbf{x}(0)=\begin{bmatrix}3\\2\\5\end{bmatrix}.$$

Compute $\mathbf{x}(100)$.

國立中山大學109學年度
碩士暨碩士專班招生考試試題

科目名稱：計算機結構【電機系碩士班己組】

—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，不得另攜帶紙張，請衡酌作答。
- 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，其後果由考生自行負擔。
- 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109學年度碩士暨碩士專班招生考試試題

科目名稱：計算機結構【電機系碩士班己組】　　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）　　

1. [20%] (1) (8%) Add one-sentence comments to each of the following MIPS code to describe what it computes. (2) (12%) Write the C code that corresponds to the following MIPS code. Assume that registers $a1 and $a2 stores the base address of arrays A and B, and the register $t1 stores the value of a variable i.

```
li $t1, 0

for: lw $s1, $s1($a1)

     beq $s1 0, end
     lw $s2, $s1($a2)

     add $s1, $s2, $s1
     add $s1, $s1, $t1

     addi $t1, $s0, 1

     bne $t1 20, for
end:
```

2. [20%] Explain the following terms.

(a) (4%) Amdahl's law
(b) (4%) Data hazard
(c) (4%) Exceptions
(d) (4%) Flush
(e) (4%) Spatial locality

3. [20%] Give answers to the following questions.

(a) (4%) Given a single precision IEEE 754 bit stream S: 1011 1110 1110 0000 0000 0000 0000 0000. What does this floating number mean? Write your final answer with decimal expression.
(b) (8%) Draw the flow chart of floating-point addition. Also explain how the floating-point addition is performed by using this flow chart.
(c) (8%) Design a hardware unit that can perform floating-point addition. Please draw the block diagram of your designed hardware unit and explain how this hardware works.

4. [20%] The following questions are for the five-pipeline-stage MIPS processor design.

(a) (5%) What are the contained pipeline stages and their tasks to be executed?
(b) (9%) Draw the **data path** of the five-pipeline-stage MIPS processor
(c) (6%) For the lw instruction, which control signals are needed and how are these control signals transferred with pipeline operations for the data path you drew in (b)?

5. [20%] Cache memory

(a) (4%) What are direct-mapped cache, set-associative cache and fully associative cache?
(b) (6%) Draw the architecture of a four-way set-associative cache that contains totally 16 blocks.
(c) (6%) Draw the flow chart of the cache architecture you drew in (b) and explain how the cache works with this flow chart.
(d) (4%)What is the "write-through" scheme? What is the possible problem with this scheme and how can we solve the problem?