國立中山大學 105 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：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. (10%) An operational amplifier has a rated output voltage of ±10 V and a slew rate (SR) of 2 V/μs. (a) What is its full-power bandwidth f_M? (b) If an input sinusoidal signal with frequency $f = 5f_M$ is applied to a unity-gain follower configuration as shown in Fig. 1, what is the maximum possible amplitude that can be accommodated at the output without incurring SR distortion? (5%*2)

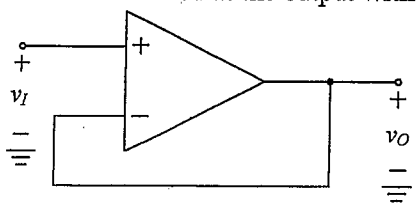

Fig. 1

2. (10%) Consider a circuit of Fig. 2 with a BJT device having β = 100 when it is biased in the active region. The constant voltage drop 0.7 V approximation can be used for the turn-on of a p-n junction, and the constant voltage drop V_{CE} ~ 0.2 V approximation can be used when the BJT is biased in the saturation region. Please calculate the collector current I_C and base current I_B. (5%*2)

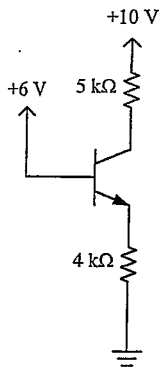

Fig. 2

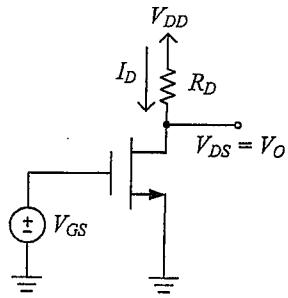

Fig. 3(a)

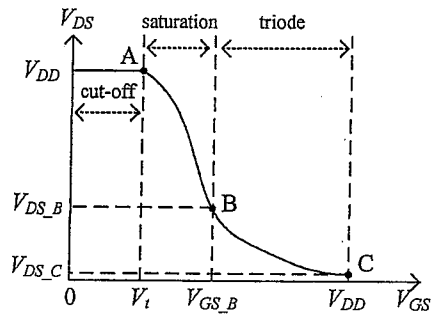

Fig. 3(b)

3. (15%) Consider the voltage amplifier of Fig. 3(a) with V_{DD} = 2 V, R_D = 20 kΩ, and with a MOSFET specified to have V_t = 0.5 V, $C_{ox}\mu_n(W/L)$ = 5 mA/V^2, and λ = 0 V^{-1}. Calculate the V_{DS_B}, V_{GS_B}, and V_{DS_C} of the voltage transfer characteristic as shown in Fig. 3(b). (5%*3)

4. (15%) Consider the voltage amplifier of Fig. 4 with a MOSFET specified to have V_t = 1.5 V, $C_{ox}\mu_n(W/L)$ = 0.5 mA/V^2, and λ = 0.02 V^{-1}. The coupling capacitors C can block DC component and pass AC component. Calculate (a) the small-signal voltage gain v_o/v_{sig}, (b) its input resistance R_{in}, and (c) the largest allowable input signal. (5%*3)

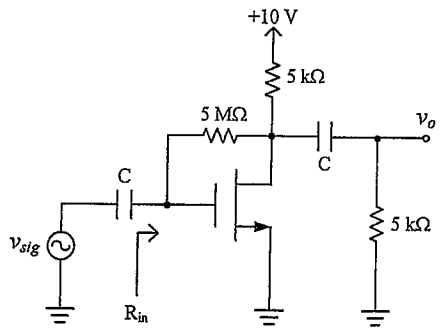

Fig. 4

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國立中山大學 105 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：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. (25%) Consider the voltage amplifier of Fig. 5 with two BJT devices: Q1 and Q2, having $\beta = 100$ when they are biased in the active region. The coupling capacitors C can block DC component and pass AC component. The voltage supplies are 10 V and the thermal voltage $V_T = 25.9$ mV. The constant voltage drop 0.7 V approximation can be used for the turn-on of a p-n junction. In addition, other resistances are also included in the Fig. 5. Please come out the following parameters: (a) DC base voltage of Q1: V_{B1}, (b) DC base voltage of Q2: V_{B2}, (c) DC collector voltage of Q2: V_{C2}, (d) overall AC voltage gain v_o/v_{sig}. (5%, 5%, 5%, 10%)

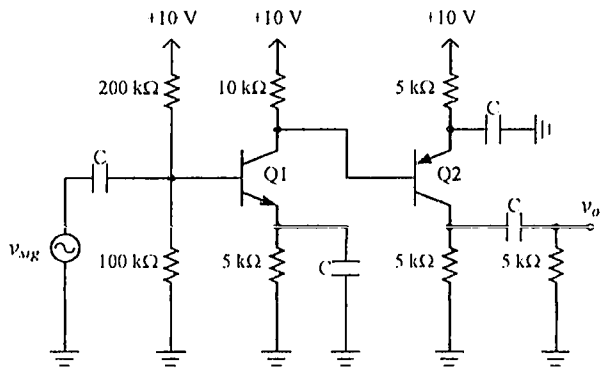

Fig. 5

6. (25%) Consider the voltage amplifier of Fig. 6 with a BJT device having $\beta = 100$ when it is biased in the active region. The coupling capacitors $C_1 = C_2 = C_3 = 1$ μF. The voltage supplies are 5 V and the thermal voltage $V_T = 25.9$ mV. If the transistor is specified to have $f_T = 700$ MHz and $C_\mu = 1$ pF. The constant voltage drop 0.7 V approximation can be used for the turn-on of a p-n junction. In addition, other resistances are also included in the Fig. 6. Please calculate (a) f_1, f_2, f_3 (let $f_1 < f_2 < f_3$) values of the low-frequency transfer function $\frac{v_o}{v_{sig}} = A_M\left(\frac{s}{s+2\pi f_1}\right)\left(\frac{s}{s+2\pi f_2}\right)\left(\frac{s}{s+2\pi f_3}\right)$, (b) the upper 3-dB frequency f_H by using open-circuit time constants method if the r_o and r_x effect are neglected. (5%*3, 10%)

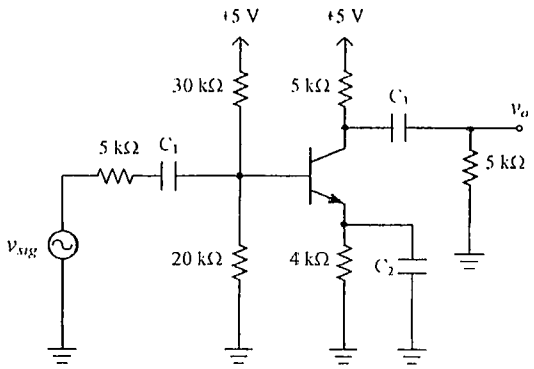

Fig. 6

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國立中山大學105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：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

Dielectric constant: Si = 11.9 ; SiO_2 = 3.9

1. An abrupt p^+-n silicon junction is doped with $N_A = 2\times10^{19}\ cm^{-3}$ under T = 300 K. The depletion capacitance C_j = 0.7 pF at a reverse bias V_R = 8 V. The cross-sectional area of the junction is $10^{-4}\ cm^2$. Ignore the built-in voltage of the junction compared to V_R. Calculate the
   (a) doping concentration in n-side. (8%)
   (b) built-in voltage. (7%)
   (c) depletion layer width for zero bias. (7%)

2. Draw the band diagrams and explain the following cases of an ideal MOS capacitor.
   (a) accumulation (b) depletion (c) inversion (6%, 6%, 6%)

3. The following three high-κ materials are stacked together to form the gate dielectric.

material	dielectric constant	bandgap (eV)	thickness (nm)
Al_2O_3	9	8.8	20
HfO_2	25	5.8	15
La_2O_3	30	6.0	10

   (a) Calculate the total equivalent oxide thickness (EOT). (7%)
   (b) What are the voltage drops across each oxide after applying a 6 V bias? (21%)

4. Explain the following terms.
   (a) bandgap narrowing effect (5%)
   (b) transferred-electron effect (5%)
   (c) short channel effect (5%)
   (d) the Hall effect (5%)

5. The lattice constant of a face-centered-cubic structure is 3.75 Å.
   Calculate the surface density of atoms for
   (a) (100) plane (6%)
   (b) (110) plane (6%)

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國立中山大學105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：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. (25%) Consider the following differential equations:

$$\dot{x}_1(t) = -2x_1(t) + x_2(t)$$
$$\dot{x}_2(t) = \quad ax_2(t)$$

(a) (10%) For what values of a, the solution converges to zero as time approaches infinity regardless the initial conditions?

(b) (10%) Let $a = -1$, $x_1(0) = x_{10}$, $x_2(0) = x_{20}$. Find the corresponding solution.

(c) (5%) Let $a = 3$. For what values of initial conditions, the corresponding solution converges to zero as time approaches infinity?

2. (20%) It is well-known that the linear equation $A\mathbf{x} = \mathbf{b}$ with $A \in \mathbb{R}^{m\times n}$ is solvable if and only if $\mathbf{b}$ lies in the range of A, i.e. $\mathbf{b} \in R(A)$.

(a) When A is full row, i.e. $rank(A) = m$, $\mathbf{b} \in R(A)$ holds for any $\mathbf{b} \in \mathbb{R}^m$ and there are infinitely many solutions $\mathbf{x}$, unless A is square. However, among these solutions, there is *unique* one, denoted by $\mathbf{x}_{\min}$, with the smallest $\|\cdot\|_2$. 請寫出(不用推導) the formula of $\mathbf{x}_{\min}$ in terms of A and $\mathbf{b}$. (2%)

But the formula in (a) fails to compute $\mathbf{x}_{\min}$ for cases with $rank(A) < m$, e.g. $A = \begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}$. A general way to decompose any matrix, called the ***full rank decomposition*** (**f.r.d.**), helps to solve the problem. It says that any $A \in \mathbb{R}^{m\times n}$ with $rank(A) = k \le \min(m, n)$ can be decomposed as $A = BC$ with $B \in \mathbb{R}^{m\times k}$ full column and $C \in \mathbb{R}^{k\times n}$ full row. There are different ways to obtain matrices B and C, e.g. applying the elementary row and column operations to matrix A.

(b) Consider the solvable linear eqn. $\begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. By doing the elementary row operations to the augmented matrix $\left[\begin{array}{ccc|c} 1 & 2 & -1 & 1 \\ -1 & -2 & 1 & -1 \end{array}\right]$, one can see that x_1 is the leading variable and $x_2 =: \alpha$ and $x_3 =: \beta$ are two free variables set by α and β, respectively. 請寫出(不用推導) the general form of the solution $\mathbf{x}$ and the values of α and β such that the corresponding $\mathbf{x}$ has the smallest $\|\cdot\|_2$. (2%+2%+2%)

Now, let's consider the eqn. $A\mathbf{x} = BC\mathbf{x} = \mathbf{b}$ where $A = BC$ is the **f.r.d.** mentioned above.

(c) 請證明 $R(A) = R(B)$. (Hence the eqn. $BC\mathbf{x} = \mathbf{b}$ is solvable if and only if $\mathbf{b} \in R(B)$.) (3%)

(d) Suppose $\mathbf{b} \in R(B)$. 請推證出 the *unique* solution $\mathbf{x}_{\min}$ with the smallest $\|\cdot\|_2$. (5%)

(e) Derive an **f.r.d.** of $A = \begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}$ and use the formula expressed in (d) to compute the solution $\mathbf{x}_{\min}$ and $\|\mathbf{x}_{\min}\|_2$ of the linear eqn. $\begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. (需推導並計算) (4%)

3. (25%) Let $P = \begin{bmatrix} 1 & \alpha \\ \beta & \gamma \end{bmatrix}$ be a projection or an idempotent matrix over $\mathbb{R}^2$.

(a) 請寫出(不用推導) the set S of all possible P with $rank(P) = 1$. (4%)

From the obtained set S you'll see that the elements of S can actually be classified into two groups, one group depends on the parameter α, denoting these elements by P_α, and the other group depends on the

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parameter β, denoting these elements by P_β. In other words, $S=\{P_\alpha,\ \alpha\in\mathbb{R}\}\cup\{P_\beta,\ \beta\in\mathbb{R}\}$.

(b) 請寫出(不用推導) the four subspaces $R(P_\alpha)$, $N(P_\alpha)$, $R(P_\beta)$, and $N(P_\beta)$ of $\mathbb{R}^2$ in the form of the span of certain linearly independent vectors, respectively, where $R(\cdot)$ and $N(\cdot)$ represent range and null space of a matrix. Moreover, 請寫出(不用推導) all possible values of α so that the angle between $R(P_\alpha)$ and $N(P_\alpha)$ is $\pi/4$. (10%)

The next two subproblems relate the preservation of projection to sum of two projection matrices. The first one is a necessary and sufficient result for projection matrices over $\mathbb{R}^n$, while the second one is a result works for $\mathbb{R}^2$ only.

(c) Let P and Q be two projection matrices over $\mathbb{R}^n$. 請證明 $P+Q$ is also a projection matrix if and only if $PQ=QP=\mathrm{O}_n$, the $n\times n$ zero matrix. (2%+4%)

(d) Let P and Q be two *nonzero* projection matrix over $\mathbb{R}^2$. 請證明 if $P+Q$ is also a projection matrix over $\mathbb{R}^2$, then $P+Q=I_2$. (5%)

4. (17%) Let $z=x+jy$, $x, y\in R$, and $f(z)=\cos z$.

(a) (8%) Compute $|f(z)|$, express your answer in terms of $\cos x$ and $\sin hy$.

(b) (9%) Let R denote the region $0\le x\le\pi$, $0\le y\le 1$. Compute the maximum value of $|f(z)|$ in R, and find the point(s) z which achieve(s) this maximum value.

5. (a) (3%) Compute the Fourier transform $F_1(\omega)=\int_{-\infty}^{\infty}f_1(t)e^{-j\omega t}dt$ of a signal $f_1(t)$ defined as

$$f_1(t)=\begin{cases}h, & |t|<T_1\\ 0, & |t|>T_1\end{cases}.$$

(b)(4%) Let $F_2(\omega)$ be the Fourier transform of a signal $f_2(t)$. Compute the Fourier transform of $f_2(t-t_0)$.

(c)(6%) Utilize the following equation

$$\int_{-\infty}^{t}f(\tau)d\tau \ \Leftrightarrow\ \frac{1}{j\omega}F(j\omega)+\pi F(0)\delta(\omega)$$

and the formulas you obtained in (a) and (b), compute the Fourier transform of the following signal

$$f(t)=\begin{cases}0, & t<1\\ t-1, & 1\le t\le 3\\ 2, & 3<t\end{cases}$$

Credit will not be given if you use other methods.

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國立中山大學105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：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）　　

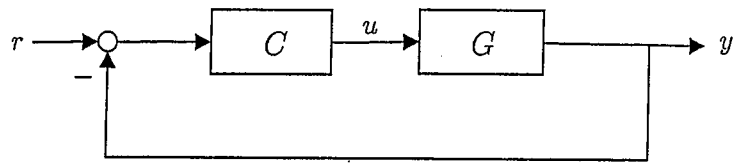

Figure 1: the feedback system for Question 1 to Question 3

Question 1 (30%)

考慮如圖 Figure 1 之回授控制系統，其中G與C分別代表受控系統及控制器。

(a) (5%) 假設 G 的動態由下列之微分方程式所支配

$$\ddot{y}(t) + b_1\dot{y}(t) + b_0 y(t) = u(t-\tau)$$

其中 b_0, b_1, τ 為常數且 $\tau \geq 0$。請推導受控系統 G 的轉移函數。

(b) (5%) 若受控系統 G 的步階響應有震盪現象，請問 b_0 與 b_1 須滿足何種條件？

(c) (5%) 假設 $b_0 = 1, b_1 = 2, \tau = 1$。請求出受控系統 G 的單位步階響應。

(d) (5%) 假設 $b_0 = b_1 = \tau = 0$。如果控制器 C 是一個相位落後補償器的話，請問閉迴路系統是否可以穩定？ 你必須提出合理的解釋而不是只回答「是」或「否」。

(e) (5%) 假設 $\tau = 0$ 且控制器 C 為比例控制器；也就是說 $u = k(r-y)$。再則，令 $b_0 > 0$，$b_1 > 0$。請用根軌跡圖解釋，為何在這種情況下任何正數 k 都將使閉迴路系統穩定。

(f) (5%) 假設 $\tau > 0$ 且控制器 C 為比例控制器。請解釋為何在這種情況下，若 k 值太大的話，閉迴路系統將會***不穩定***。

Question 2 (30%)

再次考慮如圖 Figure 1 之回授控制系統。

(a) (10%) 令 G 的轉移函數為 $\dfrac{2(s+1)}{s(s+6)}$，C 的轉移函數為 $\dfrac{K}{(s-1)}$。請找出使閉迴路系統所有極點之實部皆小於 -1 的所有K值。

(b) (10%) 令 G 的轉移函數為 $\dfrac{s+2}{s^2-1}$，C 的轉移函數為 $\dfrac{s+a}{s}$。若輸入 r 為單位斜坡函數，請推導系統響應之穩態誤差（取絕對值並將之表示為參數 a 的函數）。請問藉由調整 a 值所能造成之穩態誤差極小值（取絕對值）為何？

(c) (10%) 令 G 的轉移函數為 $\dfrac{s+2}{s^2-1}$。請設計一 PD 控制器 C 使閉迴路系統滿足以下規格：(1)最大超越量為 0.5% (2)自然頻率為 2.5。

<提示> 最大超越量$M_o = \mathrm{e}^{-\pi\xi/\sqrt{1-\xi^2}}$，其中 ξ 為系統之 damping ratio。若需計算 ξ 時，請四捨五入至小數後第二位，並用以下近似值：$\ln(0.05) = -3$。

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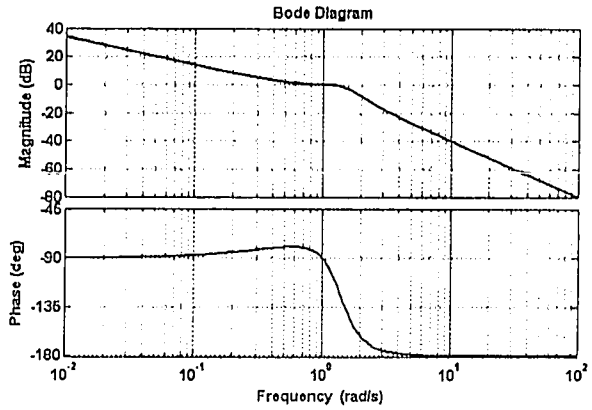
Question 3 (20%)

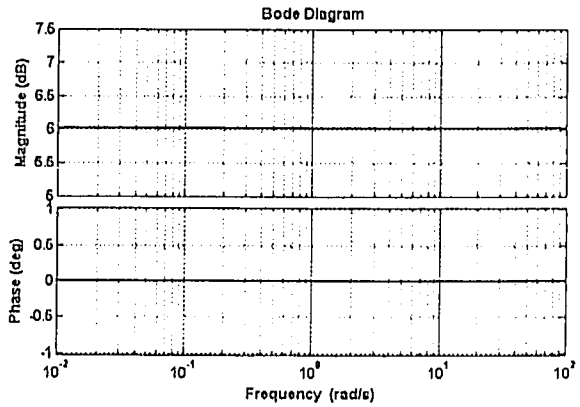
再次考慮如圖Figure 1之回授控制系統，其中 G 的Bode plot如圖3-a所示。

(a) (10%) 若控制器 C 的Bode plot如圖3-b所示 (請注意：該控制器之直流增益為 6.02 dB)。請問閉迴路系統是否為穩定？閉迴路系統的單位步階響應之穩態誤差為何？請解釋你的答案。

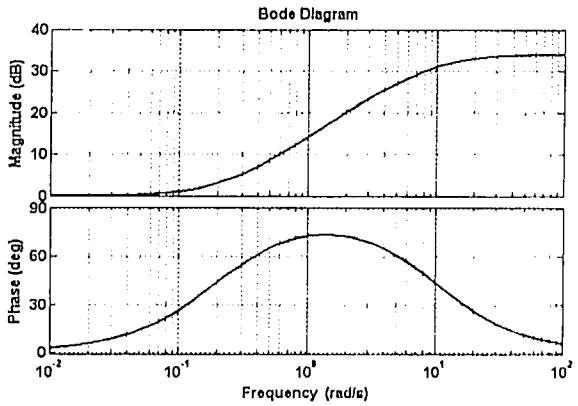
(b) (10%) 若控制器 C 的Bode plot如圖3-c所示。請問使用該控制器時補償後之開路系統的相位邊限大約為何？請問閉迴路系統之頻寬大約為何？請解釋你的答案。



[圖3-a]



[圖3-b]



[圖3-c]

Question 4 (20%)

一個系統的輸入 u 與輸出 y 之間有以下的關係：

$$y(t) = \int_0^t g(t-\tau)u(\tau)d\tau, \quad t \geq 0$$

(a) (2%) 請證明此系統為線性系統。

(b) (3%) 請證明此系統為非時變系統。

(c) (10%) 請推導此系統之轉移函數。

(d) (5%) 若 $g(t) = e^{-t}\sin t, \ t \geq 0$，請問該系統對哪一個頻率的旋波訊號造成最大的振幅放大？

End of Examination

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國立中山大學105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：431010

※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

（答題需將推導過程與原因寫出，回答到要點原因與推導的嚴謹性為主要評分考量）

1. (10%) Given Boolean variables p, q, and r where ¬p is the complement of p, ∧ is logical AND, ∨ is logical OR, and → is logical imply, prove that the following formula is true:

   $(r \wedge \neg q) \vee (p \wedge \neg r) \rightarrow p \vee \neg q$

2. (10%) In a 2D mesh region as shown in Figure 1, given a node S and a node *D*, the distance between *S* and *D* is *6* and *5* in the X and Y dimensions, respectively. A shortest route from S to D is a route with route length 11. A bend occurs when the route changes its direction from X-axis to Y-axis or vice versa. Calculate the number of possible shortest routes between *S* and *D* with 3 bends.

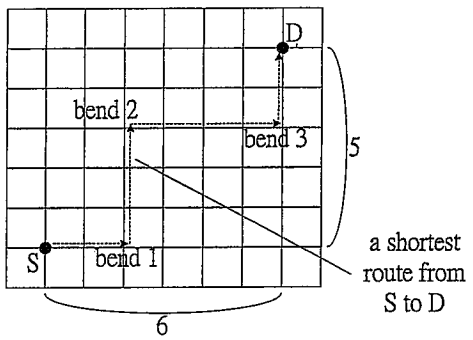


Figure 1

3. (15%) Given a bag having 1 white ball and 2 red balls, let us proceed a drawing run that a drawing takes a ball from the bag, record its color, put it back, and do such drawing for 4 times. Assume that the drawing of each distinct ball is fair (of equal probability). Calculate the probability to draw exactly 2 white balls and 2 red balls in the run.

4. (15%) Given a directed graph *G* as in Figure 2:

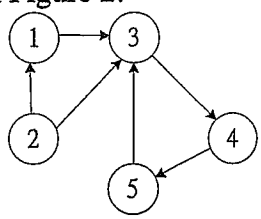


Figure 2

   (a) (5%) Derive a relation matrix *R* of the graph.

   (b) (10%) Derive the matrix of transitive closure R^* of relation *R*.

5. (15%) Write a recursive subprogram *power(x, n)* to compute x^n where *x* is an integer, $x \neq 0$ and *n* is a non-negative integer such that the subprogram has O(*log n*) time complexity.
   (Hint: $x^{2i} = (x^i)^2$, $x^{2i+1} = (x^i)^2 x$ for $i > 0$)

6. (15%) A tree is a connected graph (i.e. there is a path between any two vertices) that has no cycles (i.e. a path (of length > 0) that has its starting vertex and its ending vertex being the same vertex). Prove that between any two vertices v_i and v_j in the graph, there is a unique path (only one path) between these two vertices.

7. (20%)

   (a) (10%) Given a graph G(V,E) that is a tree (a connected graph with no cycles) and has *n* vertices and *e* edges, prove that $e = n - 1$ by strong induction.

   (b) (10%) Given a graph G(V,E) that is a forest (has *k* number of trees) and has *n* vertices and *e* edges, prove that $n = e + k$. (You can use the result of (a) of this question.)

試題隨卷繳回

國立中山大學105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：431003

※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. [7%] Suppose we have three expressions "x＊yz＋", "xy＋z＊", and "＋xyz＊". Note that x, y, and z are operands, ＊ and ＋ are arithmetic multiplication and addition, respectively, and double quotes are not part of an expression. Please answer the following questions:
   a) [2%] Which one is a postfix expression?
   b) [5%] Let x = 10, y = 20, and z = 5. Please show the value of the postfix expression.

2. [10%] Consider the following recursive definition for a language:
   <expression> = <plus> | <minus><expression> | <expression><plus>
   <plus> = +
   <minus> = —
   Please list all three-character strings that are in this language.

3. [10%] Suppose we have a min-heap of height h. Please answer the following questions:
   a) [5%] What is the minimum number of nodes this min-heap may contain?
   b) [5%] What is the maximum number of nodes this min-heap may contain?
   Note that a min-heap with one node has a height of 1.

4. [10%] Suppose we have the following 7 integers:
   70, 60, 50, 40, 30, 20, 10
   Please create an AVL tree by inserting all the above integers, from 70 to 10, one by one. Please show the resulting AVL tree.

5. [10%] Consider the following function:

```
1.  function factorial(n)
2.  {
3.    product = 0;
4.    i = 1;
5.    while(i < n+1) {
6.      product = product*i;
7.      i = i+1;
8.    }
9.    return product;
10. }
```

   Suppose the execution of statement 2 takes zero time units, the execution of statement 3 takes one time unit, the execution of statement 4 takes 1 time unit, the execution of statement 5 takes 3 time units, the execution of statement 6 takes 5 time units, the execution of statement 7 takes 2 time units, the execution of statement 8 takes zero time units, the execution of statement 9 takes one time unit, and the execution of statement 10 takes zero time units. Please answer the following questions:
   a) [7%] How many time units are required for a call of factorial(n)? Note that only statements 2 to 10 need to be considered.
   b) [3%] What is the time complexity, expressed in big-O, of this function?

6. [10%] Suppose we have the following 10 integers:
   70, 64, 44, 82, 18, 33, 30, 95, 50, 55
   Please create a hash table with 13 entries by inserting the integers one by one and from the left to the right. Assume the hash function is h(k) = k%13 and linear probing is used for collision resolution. Note that % yields the remainder when one integer is divided by another. For example, 20%13 = 7 and 5%13 = 5.

7. [8%] Consider Figure 1(a) and Figure 1(b).

試題隨卷繳回　背面有題

a) [3%] Which one is not a max-heap?

b) [5%] Please adjust the illegal one to a max-heap with the least number of exchanges. Please show the resulting max-heap.

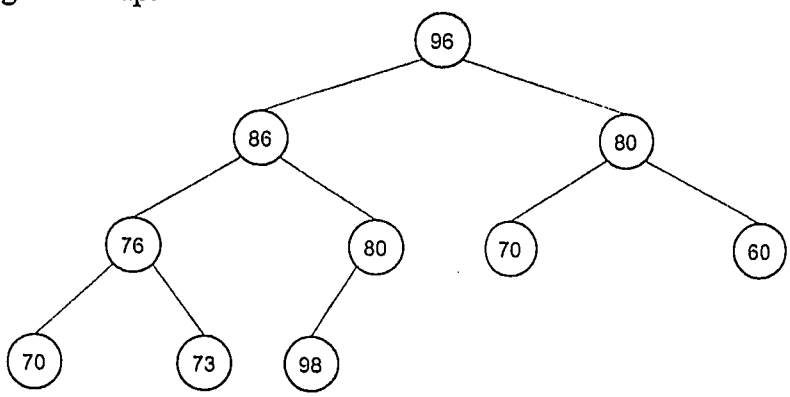


Figure 1(a)

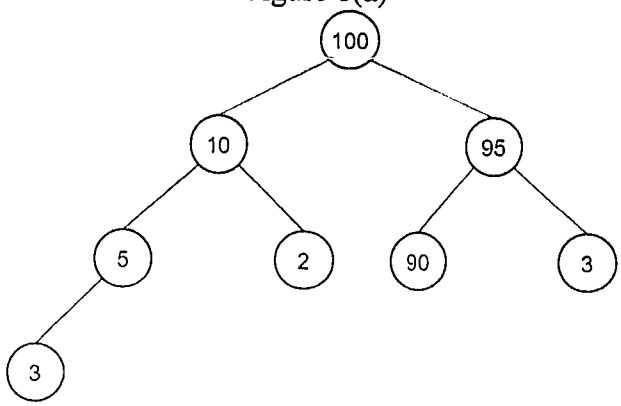


Figure 1(b)

8. [15%] Consider the binary search tree of Figure 2.

a) [5%] Please show the postorder traversal of Figure 2.

b) [5%] Please show the preorder traversal of Figure 2.

c) [3%] Please delete 45 from Figure 2 and show the resulting binary search tree. Note that a deleted node is replaced by another node which is greater than and closest to it.

d) [2%] Please insert 85 into Figure 2 and show the resulting binary search tree.

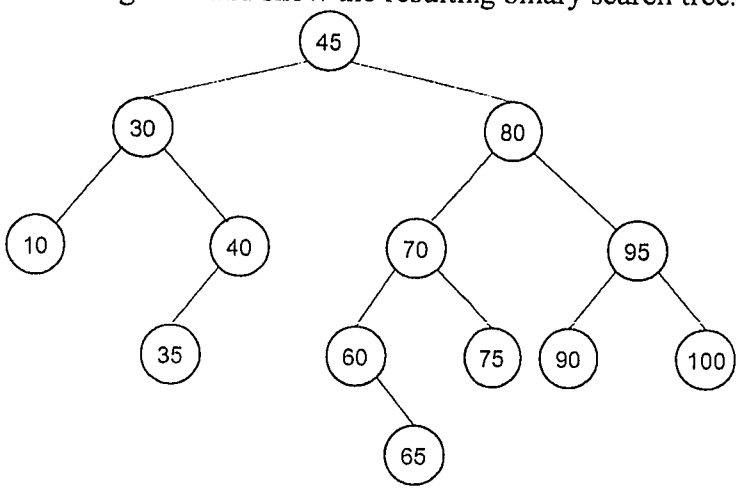


Figure 2

9. [10%] Consider the graph of Figure 3.

a) [2%] Please show the adjacency matrix of this graph.

b) [8%] Please list all the paths of length 3 in this graph. Note that a path of length 3 consists of

three edges.

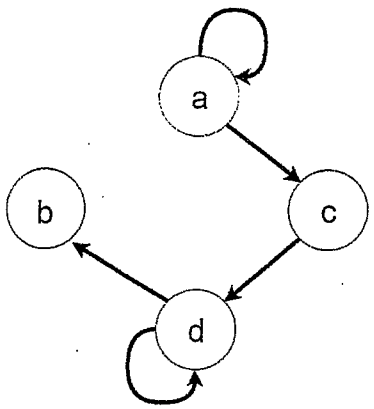


Figure 3

10. [10%] Please answer the following questions in big-O:
    a) [2%] If using an array to implement the push and pop operations of a stack, what is the time complexity of this implementation for each operation? Please describe your implementation and explain your answers.
    b) [2%] If using a linked list to implement the enqueue and dequeue operations of a queue, what is the time complexity of this implementation for each operation? Please describe your implementation and explain your answers.
    c) [3%] If using an array to implement the search, deletion, and insertion operations of an ordered sequence of numbers, what is the time complexity of this implementation for each operation? Please describe your implementation and explain your answers.
    d) [3%] If using a linked list to implement the search, deletion, and insertion operations of an ordered sequence of numbers, what is the time complexity of this implementation for each operation? Please describe your implementation and explain your answers.

Wish You Good Luck!

國立中山大學105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：431005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（單選題共20題）　

每題正確答案得5分，錯誤答案倒扣1分，未作答者，不給分亦不扣分

1. A Lithium Ion battery module rated at 12V/6Ah is discharged by 0.25C constant current for 2 hours. Determine the total energy released from the battery.
   Ⓐ、144Wh
   Ⓑ、72Wh
   Ⓒ、36Wh
   Ⓓ、18Wh

2. In a DC circuit, a load is connected to a Thevenin's equivalent circuit (Thevenin voltage=200V, Thevenin resistance=10Ω). Determine the maximum power consumed by the load.
   Ⓐ、2000W
   Ⓑ、1000W
   Ⓒ、500W
   Ⓓ、250W

3. For a DC circuit, choose a false statement.
   Ⓐ、inductor becomes short circuit
   Ⓑ、capacitor becomes open circuit
   Ⓒ、instantaneous power is constant
   Ⓓ、average current is equal to zero

4. For an ideal OP amplifier, choose a false statement.
   Ⓐ、input impedance is zero
   Ⓑ、output impedance is zero
   Ⓒ、OP gain is infinite
   Ⓓ、voltage difference between two input terminals is zero

5. Determine the time constant of a RL first-order circuit with L=4H and R=2Ω.
   Ⓐ、4s
   Ⓑ、2s
   Ⓒ、1s
   Ⓓ、0.5s

6. Determine the condition for a series RLC second-order circuit with underdamped response.
   Ⓐ、the damping factor is less than the resonant frequency
   Ⓑ、the damping factor is equal to the resonant frequency
   Ⓒ、the damping factor is larger than the resonant frequency
   Ⓓ、the damping factor is equal to zero

7. In an AC circuit, choose a false statement.
   Ⓐ、the impedance of an inductor increases with increasing frequency
   Ⓑ、the impedance of a capacitor decreases with increasing frequency
   Ⓒ、the impedance is defined as voltage phasor divided by current phasor
   Ⓓ、the impedance is a phasor

國立中山大學105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：431005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（單選題共20題）　

每題正確答案得5分，錯誤答案倒扣1分，未作答者，不給分亦不扣分

8. In TAIWAN, single-phase three-wire 110V is common in domestic power system. Choose a false statement.
   Ⓐ、110V is RMS value.
   Ⓑ、System frequency is 60Hz
   Ⓒ、This system is able to provide single-phase 220V connection
   Ⓓ、This system is able to provide three-phase 220V connection

9. In AC circuit analysis, choose a false statement.
   Ⓐ、phasor analysis can be used to determine sinusoidal steady-state response
   Ⓑ、phasor analysis can be used to determine sinusoidal complete response
   Ⓒ、Laplace transform can be used to determine sinusoidal steady-state response
   Ⓓ、Laplace transform can be used to determine sinusoidal complete response

10. How to calculate the average power consumed by an AC circuit?
   Ⓐ、voltage times current
   Ⓑ、voltage divided by current
   Ⓒ、voltage square divided by impedance
   Ⓓ、current square times resistance

11. What is the definition of power factor?
   Ⓐ、average power divided by apparent power
   Ⓑ、average power divided by reactive power
   Ⓒ、cosine function of angle different between voltage and current
   Ⓓ、cosine function of impedance angle

12. Determine the power factor of a load with impedance $10+j10\Omega$.
   Ⓐ、0.707 leading
   Ⓑ、0.707 lagging
   Ⓒ、1
   Ⓓ、0

13. In a three-phase three-wire circuit, choose a false statement.
   Ⓐ、line current may contain zero-sequence component
   Ⓑ、line current may contain negative-sequence component
   Ⓒ、unbalanced load draws unbalanced current among phases
   Ⓓ、power consumption may be different in different phase

14. A delta-connected load 100Ω per phase is connected to a balanced three-phase three-wire 200V circuit. Choose a false statement.
   Ⓐ、power factor is unity
   Ⓑ、reactive power is zero
   Ⓒ、the average power is equal to the instantaneous power in each phase
   Ⓓ、line current is balanced

國立中山大學105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：431005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（單選題共20題）　

每題正確答案得5分，錯誤答案倒扣1分，未作答者，不給分亦不扣分

15. For a two-winding coupling device in an AC circuit, choose a false statement.
   Ⓐ、stored energy in the coupling device is constant
   Ⓑ、coupling coefficient is less than 1
   Ⓒ、the magnitude of induced voltage is dependent on the mutual inductance
   Ⓓ、the polarity of induced voltage can be determined by Lenz's law

16. For a RLC series resonant circuit, choose a false statement.
   Ⓐ、resonant condition is that circuit impedance is pure resistance
   Ⓑ、resonance frequency is dependent on L and C
   Ⓒ、quality factor can be increased by reducing R
   Ⓓ、voltage across L is equal to zero at resonance

17. Voltage across on a 10Ω resistor is 100cos(377t) V. Determine average power of the load.
   Ⓐ、2000W
   Ⓑ、1000W
   Ⓒ、500W
   Ⓓ、250W

18. An ideal boost converter is operated in CCM mode. Input voltage is 10V and output voltage is 50V. Determine the duty ratio of the switch in the converter.
   Ⓐ、0.2
   Ⓑ、0.8
   Ⓒ、0.25
   Ⓓ、0.833

19. A 6-pole synchronous generator is operated at 480V/50Hz. Determine the speed of rotation of the generator.
   Ⓐ、1000rpm
   Ⓑ、1800rpm
   Ⓒ、500rpm
   Ⓓ、900rpm

20. A 208V, 4-pole, 60Hz induction motor has a full-load slip 5%. Determine the rotor speed.
   Ⓐ、1890rpm
   Ⓑ、1800rpm
   Ⓒ、1710rpm
   Ⓓ、90rpm

國立中山大學105學年度碩士暨碩士專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、電波領域聯合】　　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2頁第1頁

(10%) 1. For a coaxial transmission line, Fig. a, the capacitance per unit length is $c = \frac{2\pi\varepsilon_0}{\ln\frac{b}{a}}\left[\frac{\mathrm{F}}{\mathrm{m}}\right]$, and the inductance per unit length is $\ell = \frac{\mu_0}{8\pi} + \frac{\mu_0}{2\pi}\ln\frac{b}{a}\left[\frac{\mathrm{H}}{\mathrm{m}}\right]$. Please indicate the internal and external inductances. At high frequencies, the internal inductance drops off. Find the characteristic impedance of the coaxial line, $Z_c = \sqrt{\frac{\ell}{c}}$, at high frequencies. Please also write down the unit, *i.e.*, what is square root of (H/F)?

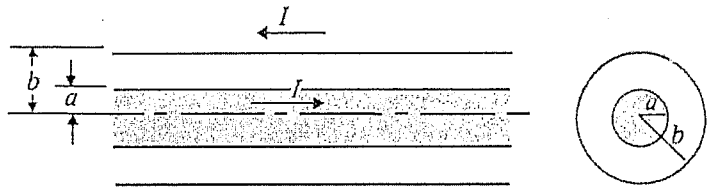


Fig. a.

(10%) 2. In the following configurations, Fig. b, assuming both grounds are perfect conductors, current directions are as indicated (the arrow on the left and a 'x' in the circle in the right); draw the image current for both cases. Using $a_n \times H = J$, determine the direction of the currents on the ground.

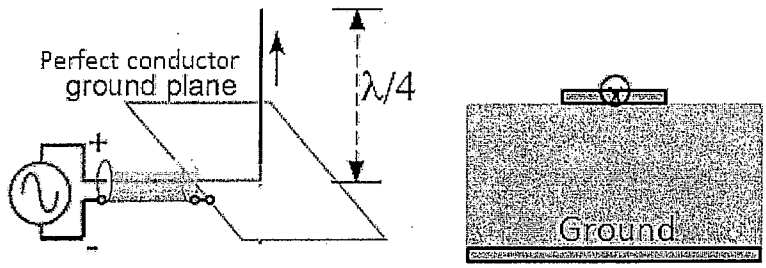
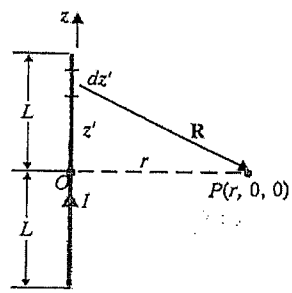


Fig. b.

Considering both the original current and its image current, which one, left or right, is likely to be an effective antenna structure, why?

(10%) 3.下圖 Fig. c 之 magnetic flux density B can be found as,



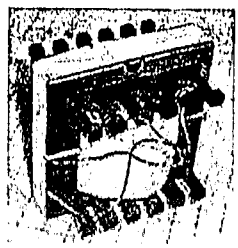
$$\mathrm{B} = \mathrm{a}_\phi \frac{\mu_0 IL}{2\pi r\sqrt{L^2+r^2}}$$

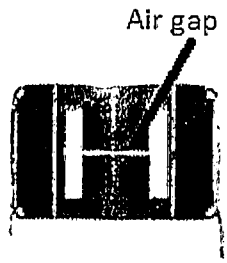
Fig. c.

簡化上列之 B as a function of r, μ_0, and a_ϕ when $L>>r$. In cylindrical coordinate system, $\nabla\cdot\mathrm{B} = \frac{1}{r}\frac{\partial}{\partial r}(rB_r) + \frac{1}{r}\frac{\partial B_\phi}{\partial\phi} + \frac{\partial B_z}{\partial z}$. Show that $\nabla\cdot\mathrm{B} = 0$.

試題隨卷繳回　背面有題

(5%) 4. 有一變電器，如 Fig. d 圖左。細看之下變電器(中圖)裏有一 air gap. 從 $L = \Phi/I$, $\Phi = B \times A$ (A 為變電器截面積), 及右圖多組具飽合之 $B = \mu H$ 曲線之觀點，解釋 why the air gap is used.





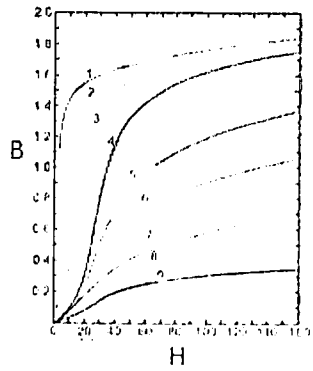


Fig. d.

(5%) 5. Using the Method of Image, write down the potential distribution, $V(x, y, z)$, for any point $P(x, y, z)$ in the space, Fig. e. The dielectric constant of the space is ε_0. Q is a positive point charge of Q *Coul*.

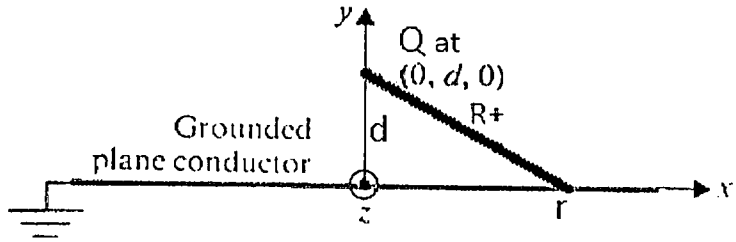


Fig. e.

6. (5%)(a) Explain Gradient, Divergence, and Curl. (5%)(b) Curl of a Gradient field, $\nabla \times \nabla V = 0$, Divergence of a Curl, $\nabla \cdot \nabla \times A = 0$. 說明其物理意義，或舉例。

7. A parallel polarized plane wave of an electric field intensity E_{i0} and an angular frequency ω is obliquely incident from free-space onto a magnetic material with permittivity ε_0 and permeability $\mu_0\mu_r$ at an angle of incidence θ_i. (10%)(a)Find the reflection and transmission coefficients and express the electromagnetic field of the incident, reflected and transmitted waves for this case. (5%)(b) Does a Brewster angle exist for this case? Explain why.

8. A lossless 50 Ω coaxial cable has a length of 6 cm and is connected to an antenna having an impedance 80+*j*40 Ω. The cable has a dielectric with $\varepsilon_r = 2.25$ and $\mu_r = 1$, and the operating frequency is 3 GHz. (10%) (a) Find the input impedance to the cable. (5%)(b) If a radio transmitter that can deliver 10 W at a load impedance of 50 Ω is connected to the input of the cable, how much power is delivered to the antenna?

9. A TE_{10} wave at 10 GHz propagates in a rectangular waveguide with inner dimensions $a = 1.5$ cm and $b = 0.6$ cm, which is filled with a dielectric having $\varepsilon_r = 2.25$, $\mu_r = 1$ and loss tangent = 3×10^{-3}. Determine (5%)(a) the TE_{10} cut-off frequency, (5%)(b) the wave impedance, (5%)(c) the attenuation constant due to dielectric loss, and (5%)(d) the energy-transport velocity.

背面有題

國立中山大學 105 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）　　共 1 頁第 1 頁

[Problem 1] Terminology Explanation (25%)
(a) Superscalar Processor (b) Multi-core Processor (c) Branch Prediction
(d) VLIW Architecture (e) Booth's multiplication algorithm

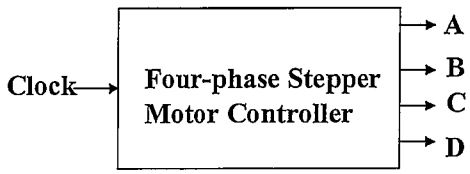
[Problem 2] (a) Describe the definition of Amdahl's law. (5%)
(b) Suppose we enhance a machine making all floating-point instructions run four times faster. If the execution time of some benchmark before the floating-point enhancement is 60 seconds, what will the speedup be if three-fourth of the 60 seconds is spent executing floating-point instructions? (10%)

[Problem 3] A set associative cache has a block size of four 32-bit words and a set size of 4. The cache can accommodate a total of 16K words. The main memory size that is cacheable is 64M * 32 bits. Design the cache structure and show how the processor's addresses are interpreted. (20%)

[Problem 4] (1)Design a Four-phase Stepper Motor Controller circuit with a clock input to generate the output signals A, B, C and D to control a four-phase stepper motor whose stepping waveform is described as table 1. (10%)
(2) In Verilog HDL, write the Four-phase Stepper Motor Controller Module. (10%)

Table 1

step	Output signals			
	A	B	C	D
1	1	1	0	0
2	1	0	0	1
3	0	0	1	1
4	0	1	1	0
1	1	1	0	0



[Problem 5] Use the following code fragment:

```
Loop:   LW      R1, 0(R2)
        ADDI    R1, R1, #1
        SW      0(R2), R1
        ADDI    R2, R2, #4
        SUB     R4, R3, R2
        BNEZ    R4, Loop
```

Assume the initial value of R3 is R2+100. Use the five-stage instruction pipeline (IF, DEC, EXE, MEM, WB) and assume all memory accesses are one cycle operation. Furthermore, branches are resolved in MEM stage.

(a) Show the timing of this instruction sequence for the five-stage instruction pipeline with normal forwarding and bypassing hardware. Assume that branch is handled by predicting it as not taken. How many cycles does this loop take to execute? (10%)
(b) Assuming the five-stage instruction pipeline with a single-cycle delayed branch and normal forwarding and bypassing hardware, schedule the instructions in the loop including the branch-delay slot. You may reorder instructions and modify the individual instruction operands, but do not undertake other loop transformations that change the number of op-code of instructions in the loop. Show a pipeline timing diagram and compute the number of cycles needed to execute the entire loop. (10%)

試題隨卷繳回

國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組】　　題號：431001

※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. (25%) Consider the differential equation:

$$\ddot{y}(t) + b\dot{y}(t) + 5y(t) = u(t)$$

(a) (5%) Let $u(t) \equiv 0$. For what range of the values of b will the solutions (w.r.t. non-zero initial conditions) to the equation exhibit oscillatory behavior.

(b) (10%) For $b = 4$. Find the forced solutions for $u(t) = 4e^{2t}\sin t$ and $u(t) = 4e^{2t}\cos t$. Express the solutions in the form of $c_1 e^{c_2 t}\sin(\omega_1 t + \phi_1)$ and $c_3 e^{c_4 t}\cos(\omega_2 t + \phi_2)$, respectively.

(c) (10%) Let $b = 2$, $u(t) = \cos\omega t$, and the initial conditions being zero. For what value of ω does the solution to the equation have the biggest amplitude.

2. (20%) Let D be the region bounded by the four curves: $xy = 1$, $xy = 3$, $y = x^2$, $2y = x^2$. Find the area of D (計算 D 的面積). **HINT**: Let $u = xy$ and $v = x^2/y$. Express $dxdy$ in terms of $dudv$.

3. (15%) The linear equation $A\mathbf{x} = \mathbf{b}$ with $A \in \mathbb{R}^{m\times n}$ is known to be solvable if and only if $\mathbf{b}$ lies in the range of A, i.e. $\mathbf{b} \in R(A)$, which is always true for a full row A, i.e. $rank(A) = m$. For such a case, the unique solution with the smallest $\|\cdot\|_2$ can be computed by a formula. However, this formula fails when $rank(A) < m$ e.g. $A = \begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}$. A general way to decompose any matrix, called the *full rank decomposition* (**f.r.d.**), helps to solve the problem. It says that any $A \in \mathbb{R}^{m\times n}$ with $rank(A) = k \le \min(m, n)$ can be decomposed as $A = BC$ with $B \in \mathbb{R}^{m\times k}$ full column and $C \in \mathbb{R}^{k\times n}$ full row. There are different ways to obtain matrices B and C, e.g. applying the elementary row and column operations to matrix A.

(a) Consider the solvable linear eqn. $\begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. By doing the elementary row operations to the augmented matrix $\left[\begin{array}{ccc|c} 1 & 2 & -1 & 1 \\ -1 & -2 & 1 & -1 \end{array}\right]$, one can see that x_1 is the leading variable and $x_2 =: \alpha$ and $x_3 =: \beta$ are two free variables set by α and β, respectively. 請寫出(不用推導) the general form of the solution $\mathbf{x}$ and the values of α and β such that the corresponding $\mathbf{x}$ has the smallest $\|\cdot\|_2$. (2%+2%+2%)

Now, let's consider the eqn. $A\mathbf{x} = BC\mathbf{x} = \mathbf{b}$ where $A = BC$ is the **f.r.d.** mentioned above. It can be shown that $R(A) = R(B)$. Hence the eqn. $BC\mathbf{x} = \mathbf{b}$ is solvable if and only if $\mathbf{b} \in R(B)$.

(b) Suppose $\mathbf{b} \in R(B)$. 請推證出 the *unique* solution $\mathbf{x}_{min}$ with the smallest $\|\cdot\|_2$. (5%)

(c) Derive an **f.r.d.** of $A = \begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}$ and use the formula expressed in (b) to compute the solution $\mathbf{x}_{min}$ and $\|\mathbf{x}_{min}\|_2$ of the linear eqn. $\begin{bmatrix} 1 & 2 & -1 \\ -1 & -2 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. (需推導並計算) (2%+2%)

4. (10%) Let $P = \begin{bmatrix} 1 & \alpha \\ \beta & \gamma \end{bmatrix}$ be a projection or an idempotent matrix over $\mathbb{R}^2$.

(a) 請寫出(不用推導) the set S of all possible P with $rank(P) = 1$. (4%)

From the obtained set S you'll see that the elements of S can actually be classified into two groups, one group depends on the parameter α, denoting these elements by P_α, and the other group depends on the

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parameter β, denoting these elements by P_β. In other words, $S=\{P_\alpha,\ \alpha\in\mathbb{R}\}\cup\{P_\beta,\ \beta\in\mathbb{R}\}$.

(b) 請寫出(不用推導) the two subspaces $N(P_\alpha)$ and $R(P_\beta)$ of $\mathbb{R}^2$ in the form of the span of certain linearly independent vectors, respectively, where $R(\cdot)$ and $N(\cdot)$ represent range and null space of a matrix. Moreover, 請寫出(不用推導) all possible values of α so that the angle between $R(P_\alpha)$ and $N(P_\alpha)$ is $\pi/4$. (2%+2%+2%)

5. (17%) Let $z=x+jy$, $x, y\in R$, and $f(z)=\cos z$.

(a) (8%) Compute $|f(z)|$, express your answer in terms of $\cos x$ and $\sinh y$.

(b) (9%) Let R denote the region $0\le x\le\pi$, $0\le y\le 1$. Compute the maximum value of $|f(z)|$ in R, and find the point(s) z which achieve(s) this maximum value.

6. (a) (3%) Compute the Fourier transform $F_1(\omega)=\int_{-\infty}^{\infty}f_1(t)e^{-j\omega t}dt$ of a signal $f_1(t)$ defined as

$$f_1(t)=\begin{cases}h, & |t|<T_1\\ 0, & |t|>T_1\end{cases}.$$

(b) (4%) Let $F_2(\omega)$ be the Fourier transform of a signal $f_2(t)$. Compute the Fourier transform of $f_2(t-t_0)$.

(c) (6%) Utilize the following equation

$$\int_{-\infty}^{t}f(\tau)d\tau \ \Leftrightarrow\ \frac{1}{j\omega}F(j\omega)+\pi F(0)\delta(\omega)$$

and the formulas you obtained in (a) and (b), compute the Fourier transform of the following signal

$$f(t)=\begin{cases}0, & t<1\\ t-1, & 1\le t\le 3\\ 2, & 3<t\end{cases}$$

Credit will not be given if you use other methods.

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國立中山大學 105 學年度碩士暨碩士專班招生考試試題

科目名稱：電子學【電機系碩士班乙組、戊組、電波領域聯合】　　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 2 頁第 1 頁

1. (30%) A bandpass filter shown in Fig. 1 is designed to have lower cutoff frequency 100 rad/s and higher cutoff frequency 10^4 rad/s. **(a) (20%)** Give a rough estimate on the required values of C_1 and C_2. **(b) (10%)** Given an input cos(1000t), roughly determine the amplitude of associated output in steady state.

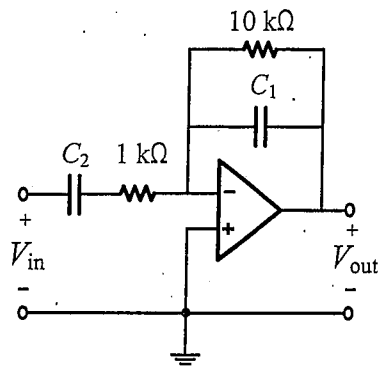

Fig. 1

2. (20%) Consider the oscillator in Fig. 2, which comprises an LCR and a non-inverting amplifier in a feedback connection. **(a) (10%)** Determine the value of R to meet the Barkhausen criterion, so as to get sustained sinewave oscillation. **(b) (10%)** Determine the capacitance C so that the circuit oscillates at 10^4 rad/s.

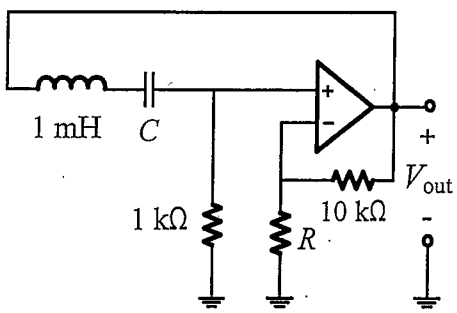

Fig. 2

3. (20%) Figure 3(a) shows a simple circuit for converting a 50-Hz ac voltage to a 24-V dc voltage, in which an ideal diode $D1$ works as a half-wave rectifier, and a 24-V zener diode $D2$ as a simple regulator. Suppose that the load current is 4 mA and the bias current of the zener diode is set to 1 mA. For simplicity, the ac source V_s is modeled as a square-wave source as shown in Fig.3(b). Determine the required resistance and the average power consumption of $R1$.

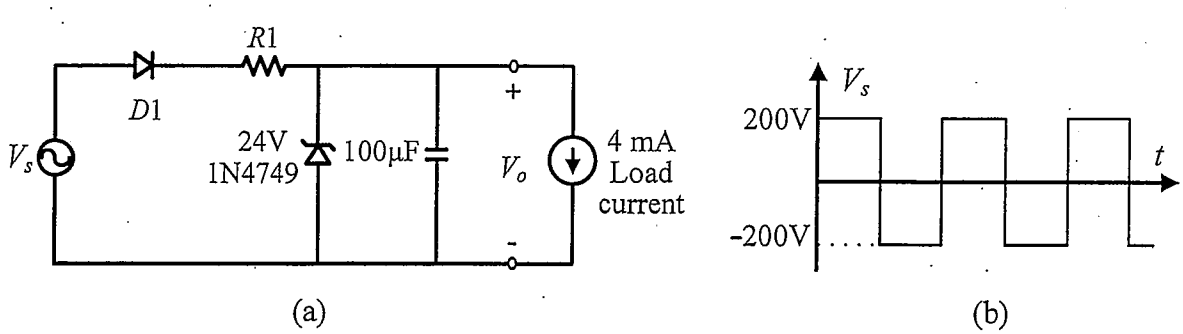

Fig. 3

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4. (30%) Figure 4 shows a common-gate MOSFET amplifier M_1 that senses the voltage at the source and produces the output at the drain. The body terminal and source terminal of MOSFET M_1 are tied together. Assume that the transistor M_1 is in saturation and it has the device parameters: W/L =500, $\mu_n C_{ox}$ = 100 μA/V^2, V_{TH}=0.5 V. To minimize wave reflection, the equivalent input resistance R_{eq} of the common-gate stage can be used to impedance match a 75-Ω coaxial cable. **(a) (20%)** Neglect the channel-length modulation. Determine V_G and I_D to meet the condition that the resistance looking into node S equals 75 Ω. **(b) (10%)** Assume the impendence of the bypass capacitor C_1 is negligibly small at the input signal frequency. Under the presumption of impedance matching, determine the amplification gain between V_{sig} and V_{out}.

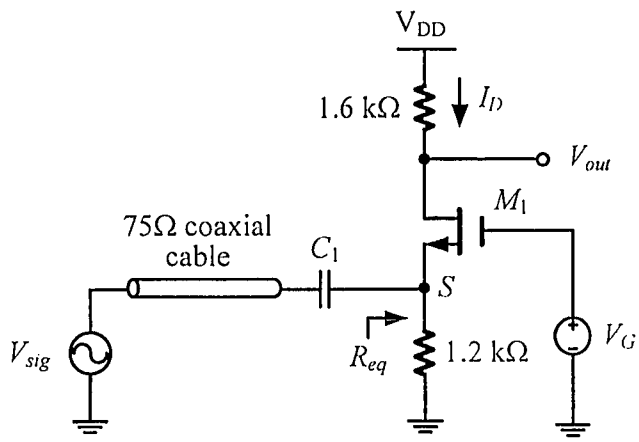

Fig. 4