國立中山大學102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）　　

1. (7%) Find the Laurent series representation of a function

$$f(z) = \frac{5z + j2}{z^2 + jz}$$

with center at $z = j$ in the domain $1 < |z - j| < 2$, $j = \sqrt{-1}$.

2. (8%) Evaluate the following integral:

$$\int_C \frac{z^3 e^{1/z}}{1 + z^3} dz,$$

where C denotes a counterclockwise simple closed contour $|z| = 3$.

3. (15%) Compute the Fourier transform $F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$ of a signum function $f(t)$ defined as

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

Each calculation step is required for obtaining the credit.

4. (20%) 下面的問題共有四個子題，**只要寫出每個子題的答案即可**(不需寫出計算過程)，例如：
(a) $\beta = 1, \gamma = 2$。

Let $\mathbf{a}_1 = \begin{bmatrix} 1 & 0 & 1 & \alpha \end{bmatrix}^T$, $\mathbf{a}_2 = \begin{bmatrix} 1 & \beta & 2 & 2 \end{bmatrix}^T$, and $\mathbf{a}_3 = \begin{bmatrix} -2 & 3 & \gamma & -4 \end{bmatrix}^T$ be three vectors in $\mathbb{R}^4$, where α, β, and γ are three real parameters, and denote $A := \begin{bmatrix} \mathbf{a}_1 & \mathbf{a}_2 & \mathbf{a}_3 \end{bmatrix} \in \mathbb{R}^{4\times 3}$.

(a) (4%) If $\alpha \in \mathbb{N}$, where $\mathbb{N}$ denotes the set of all positive integers, then find positive integers β and γ such that $\{\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3\}$ is a linearly dependent set.

(b) (4%) If $\alpha \notin \mathbb{N}$, find real β and γ such that $\{\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3\}$ is a linearly dependent set.

(c) (6%) Now let $\alpha = 2, \beta = -1, \gamma = -5$, and let $\mathbf{x}$ be a nonzero vector in the null space $N(A)$ of A. Find the value of k to satisfy $\|\mathbf{x}\|_1 + 2\|\mathbf{x}\|_\infty + k\|\mathbf{x}\|_2 = 0$.

(d) (6%) Now let $\alpha = 2, \beta = -1, \gamma = -5$, and let d denote the distance between vector $\begin{bmatrix} 1 & 4 & 0 \end{bmatrix}^T$ and $R(A^T)$, the range space of A^T. Compute the value of d.

5. (25%) 下面的問題共有四個子題，**只要寫出每個子題的答案即可**(不需寫出計算過程)，例如：
(a) $\|x\| = 1$, $\theta = 30°$或$\theta = \pi/6$。

Consider the inner product space $C[0, 1]$ with $\langle f, g \rangle := \int_0^1 f(x)g(x)dx$ and the norm $\|f\| := \sqrt{\langle f, f \rangle}$.

Denote $S := \text{span}\{1, x\}$ as a subspace of $C[0, 1]$.

(a) (3%+4%) Compute $\|x\|$ and the angle θ, taken value in $[0, \pi/2]$, between 1 and x.

(b) (6%) Find a vector $u(x)$ in $C[0, 1]$, so that $\{1, u(x)\}$ forms an orthonormal basis for S.

(c) (6%) Find the vector $p(x)$ in S that is closest to $\sqrt{x}$ on $[0, 1]$.

(d) (6%) Let $q(x)$ be the vector in $S^\perp$ that is closest to $\sqrt{x}$. Compute $\|q(x)\|^2$.

6. (20%) Consider the following system of differential equations:

$$\dot{x}_1(t) = a_{11}x_1(t) + a_{12}x_2(t)$$
$$\dot{x}_2(t) = a_{21}x_1(t) + a_{22}x_2(t) + u(t)$$

where $a_{11}, a_{12}, a_{21}, a_{22}$ are constant coefficients.

(a) (5%) Suppose $u \equiv 0$ and the equations are driven by non-zero initial conditions. Determine the conditions on the coefficients $a_{11}, a_{12}, a_{21}, a_{22}$ such that $\lim_{t\to\infty} x_1(t) = 0$ and $\lim_{t\to\infty} x_2(t) = 0$.

(b) (10%) Let the initial conditions be equal to zero. For the values $a_{11} = -1$, $a_{12} = 1$, $a_{21} = 0$, $a_{22} = -1$, and

$$u(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases}$$

calculate the response $y(t) = 2x_1(t) - x_2(t)$. Determine at what time the peak value of y occurs.

(c) (5%) For the values $a_{11} = 0$, $a_{12} = 1$, $a_{21} = -1$, $a_{22} = -2$, and $u(t) = \sin(t)$, calculate the steady-state response of $y(t) = x_1(t) - x_2(t)$.

7. (5%) Prove the following statements

(a) (3%) The Laplace transform is a linear operation.

(b) (2%) Suppose the Laplace transform of a function $y(t)$ is equal to $Y(s)$. Then the Laplace transform of $y(t-a)$ is equal to $\mathrm{e}^{-sa}Y(s)$.

國立中山大學102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、丙組選考、丁組、戊組、己組】　題號：431002

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　

1. (7%) Find the Laurent series representation of a function

$$f(z) = \frac{5z + j2}{z^2 + jz}$$

with center at $z = j$ in the domain $1 < |z - j| < 2$, $j = \sqrt{-1}$.

2. (8%) Evaluate the following integral:

$$\int_C \frac{z^3 e^{1/z}}{1 + z^3} dz,$$

where C denotes a counterclockwise simple closed contour $|z| = 3$.

3. (15%) Compute the Fourier transform $F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$ of a signum function $f(t)$ defined as

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

Each calculation step is required for obtaining the credit.

4. (15%) 下面的問題共有三個子題，**只要寫出每個子題的答案即可**(不需寫出計算過程)，例如：
(a) $\beta = 1, \gamma = 2$。

Let $\mathrm{a}_1 = \begin{bmatrix} 1 & 0 & 1 & \alpha \end{bmatrix}^T$, $\mathrm{a}_2 = \begin{bmatrix} 1 & \beta & 2 & 2 \end{bmatrix}^T$, and $\mathrm{a}_3 = \begin{bmatrix} -2 & 3 & \gamma & -4 \end{bmatrix}^T$ be three vectors in $\mathbb{R}^4$, where α, β, and γ are three real parameters, and denote $A := \begin{bmatrix} \mathrm{a}_1 & \mathrm{a}_2 & \mathrm{a}_3 \end{bmatrix} \in \mathbb{R}^{4\times 3}$.

(a) (4%) Suppose α is not a positive integer. Find real β and γ such that $\{\mathrm{a}_1, \mathrm{a}_2, \mathrm{a}_3\}$ is a linearly dependent set.

(b) (5%) Now let $\alpha = 2, \beta = -1, \gamma = -5$, and let x be a nonzero vector in the null space $N(A)$ of A. Find the value of k to satisfy $\|\mathrm{x}\|_1 + 2\|\mathrm{x}\|_\infty + k\|\mathrm{x}\|_2 = 0$.

(c) (6%) Now let $\alpha = 2, \beta = -1, \gamma = -5$, and let d denote the distance between vector $\begin{bmatrix} 1 & 4 & 0 \end{bmatrix}^T$ and $R(A^T)$, the range space of A^T. Compute the value of d.

5. (10%) 下面的問題共有二個子題，**只要寫出每個子題的答案即可**(不需寫出計算過程)，例如：
(a) $\theta = 30°$或$\theta = \pi/6$。

Consider the inner product space $C[0, 1]$ with $\langle f, g \rangle := \int_0^1 f(x)g(x)dx$ and the norm $\|f\| := \sqrt{\langle f, f \rangle}$.

Denote $S := \mathrm{span}\{1, x\}$ as a subspace of $C[0, 1]$.

(a) (4%) Compute the angle θ, taken value in $[0, \pi/2]$, between 1 and x.

(b) (6%) Find a vector $u(x)$ in $C[0, 1]$, so that $\{1, u(x)\}$ forms an orthonormal basis for S.

6. (20%) Consider the following system of differential equations:

$$\dot{x}_1(t) = a_{11}x_1(t) + a_{12}x_2(t)$$
$$\dot{x}_2(t) = a_{21}x_1(t) + a_{22}x_2(t) + u(t)$$

where $a_{11}, a_{12}, a_{21}, a_{22}$ are constant coefficients.

(a) (5%) Suppose $u \equiv 0$ and the equations are driven by non-zero initial conditions. Determine the conditions on the coefficients $a_{11}, a_{12}, a_{21}, a_{22}$ such that $\lim_{t\to\infty} x_1(t) = 0$ and $\lim_{t\to\infty} x_2(t) = 0$.

(b) (10%) Let the initial conditions be equal to zero. For the values $a_{11} = -1$, $a_{12} = 1$, $a_{21} = 0$, $a_{22} = -1$, and

$$u(t) = \begin{cases} 1 & t \geq 0 \\ 0 & t < 0 \end{cases}$$

calculate the response $y(t) = 2x_1(t) - x_2(t)$. Determine at what time the peak value of y occurs.

(c) (5%) For the values $a_{11} = 0$, $a_{12} = 1$, $a_{21} = -1$, $a_{22} = -2$, and $u(t) = \sin(t)$, calculate the steady-state response of $y(t) = x_1(t) - x_2(t)$.

7. (15%) Consider the region R enclosed by the x-axis, $x = 1$ and $y = x^3$, as illustrated below

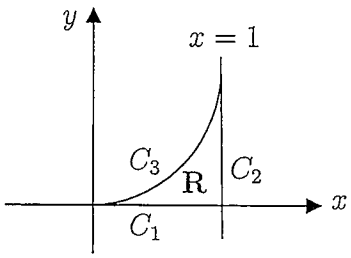


Fig. 1

(a) (3% + 2%) Find the flux of $\vec{F} = (1 + y^2)\mathbf{j}$ out of R through the two sides C_1 (the horizontal segment) and C_2 (the vertical segment).

(b) (10%) Find the flux of $\vec{F} = (1 + y^2)\mathbf{j}$ out of the third side C_3.

8. (10%) Consider the following Lyapunov equation

$$XA + A^T X + Q = 0$$

where A is a (n-dimensional) real square matrix, and X, Q are real symmetric matrices.

(a) (5%) Suppose all eigenvalues of A have negative real parts. Show that $X = \int_0^\infty e^{A^T\tau} Q e^{A\tau} d\tau$ is a solution to the Lyapunov equation.

(b) (5%) Suppose Q is positive definite and the Lyapunov equation has a positive definite solution X. Show that all eigenvalues of A have negative real parts.

國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：離散數學【電機系碩士班丙組選考】　　題號：431003

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

考生請注意：1. 必須寫出作答過程或得到答案之理由，只寫答案不予計分。
2. 禁止在試題紙上作答。
3. 參考公式請見下頁。

1. Explain the following terms : [20%, 每小題5分]
   (a) Fundamental Theorem of Arithmetic
   (b) Homeomorphic graph
   (c) Equivalence relation
   (d) Four-color Theorem

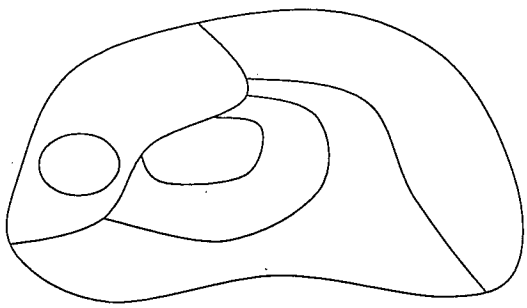
2. Given a number $x = 329313600$, please answer the following questions.
   (a) How many positive divisors does x have? [5%]
   (b) How many positive divisors of x that are divisible by 252? [5%]
   (c) Determine how many positive divisors of x are perfect squares? [5%]

3. (a) If an equivalence relation R on set $A = \{1,2,3,4,5\}$ induces the partition $A = \{1,3\} \cup \{2,4\} \cup \{5\}$, what is R? [5%]
   (b) Let $R=\{(1,1),(1,2),(2,2),(2,4), (3,3) ,(3,4),(4,5),(5,5)\}$ be a relation on A. What is the relation R^3 ? [5%]

4. What is the Ferrers graph? Use it to explain the statement "The number of partitions of an integer n into m summands is equal to the number of partitions of n into summands where m is the largest summand". [10%]

5. Use the generating function to find the number of integer solutions of the equation $x_1 + x_2 + x_3 + x_4 = 20$, where $-3 \le x_1, -3 \le x_2, -5 \le x_3 \le 5$, and $0 \le x_4$. [15%]

6. Find the number of colors needed to color the following map so that no two adjacent regions have the same color. [15%]



7. Find the number of permutation of the letters x, x, y, y, z, z so that no x appears in the first and second positions, no y appears in the third position and no z appears in the fifth and sixth positions. [15%]

國立中山大學102學年度碩士暨碩士專班招生考試試題

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Appendix:

1. $(1+x)^n = \binom{n}{0} + \binom{n}{1}x + \binom{n}{2}x^2 + \cdots + \binom{n}{n}x^n$
2. $(1+ax)^n = \binom{n}{0} + \binom{n}{1}ax + \binom{n}{2}a^2x^2 + \cdots + \binom{n}{n}a^nx^n$
3. $(1+x^m)^n = \binom{n}{0} + \binom{n}{1}x^m + \binom{n}{2}x^{2m} + \cdots + \binom{n}{n}x^{nm}$
4. $a(1-x^{n+1})/(1-x) = a + ax + ax^2 + \cdots + ax^n$
5. $1/(1-x) = 1 + x + x^2 + \cdots = \sum_{i=0}^{\infty} x^i$
6. $1/(1-ax) = 1 + ax + a^2x^2 + \cdots = \sum_{i=0}^{\infty} a^ix^i$
7. $1/(1+x)^n = 1 + (-1)\binom{n+1-1}{1}x + (-1)^2\binom{n+2-1}{2}x^2 + \cdots = \sum_{i=0}^{\infty}(-1)^i\binom{n+i-1}{i}x^i$
8. $1/(1-x)^n = 1 + (-1)\binom{n+1-1}{1}(-x) + (-1)^2\binom{n+2-1}{2}(-x)^2 + \cdots = \sum_{i=0}^{\infty}\binom{n+i-1}{i}x^i$
9. $e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots = \sum_{i=0}^{\infty}\frac{x^i}{i!}$

國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：資料結構【電機系碩士班丙組選考】　　題號：431004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

注意事項

一、不可於試題紙上作答。

二、 When you are asked to derive the running time of a program (or an algorithm) in the form of $O(f(n))$, the function $f(n)$ should be expressed in the ***simplest*** and ***tightest*** form. For example, if running time $T(n)=5n^2+4n$, you should write $T(n)=O(n^2)$. In other words, you will get 0 points if you write $T(n)=O(n^3)$ or $T(n)=O(5n^2+4n)$.

1. (a) [5 points] Given the size n of the input data, where n is a positive integer, we assume that the running time of a program is $O(f(n))$. State the *formal* definition of $O(f(n))$.

   (b) [5 points] Let $T_1(n)=\frac{1}{1}+\frac{1}{2}+\frac{1}{3}+\cdots+\frac{1}{n}=\sum_{x=1}^{n}\frac{1}{x}$. Tell us the value of $\lim_{n\to\infty}T_1(n)$. Note that you will get 0 points if you just provide the answer. In other words, you *must* show your reasons.

   (c) [5 points] Given the size n of the input data, where n is a positive integer, we assume that a program requires the running time $T_1(n)=O(f(n))$. Derive the function $f(n)$.

   (d) [5 points] Let n be the radius of a circle C and $A(n)$ be the area of C. Let $T_2(n)=|\sin\theta|\times\log A(n)=O(f(n))$. Derive the function $f(n)$.

2. [5 points] Consider the following function **F** written in a C-like pseudo-code, which takes an array **A** of n positive integers and an initially-empty stack **S** as input parameters:

```
int F(A: array, S: stack) {
   int i, t=0;

   for (i=0; n-1; i++) {
      if (A[i]%2==0)
        push(S, A[i]);
      else
        while (S is not empty)
           t = t + pop(S);
   } // end of for-loop
   while (S is not empty)
      t = t + pop(S);
   return t;
}
```

   What is the output (returned value) of the function **F** for the array **A = {2, 14, 4, 7, 11, 18, 10, 15, 6, 23, 12, 8}**?

3. Consider the following weighted graph $G(V,E)$ presented by the adjacency matrix.

$$G = \begin{array}{c} \\ A \\ B \\ C \\ D \\ E \\ F \end{array} \begin{array}{c} \begin{array}{cccccc} A & B & C & D & E & F \end{array} \\ \begin{bmatrix} 0 & 40 & \infty & \infty & 7 & 21 \\ 40 & 0 & 5 & 12 & \infty & 11 \\ \infty & 5 & 0 & 10 & \infty & \infty \\ \infty & 12 & 10 & 0 & 18 & 14 \\ 7 & \infty & \infty & 18 & 0 & 33 \\ 21 & 11 & \infty & 14 & 33 & 0 \end{bmatrix} \end{array}$$

(1) [10 points] Please find the vertex sequence derived by DFS and BFS respectively. Note that we assume that node A is the root.
(2) [10 points] Please apply Kruskal's algorithm to drive the minimum cost spanning tree. Note that you *must* show your actions step by step.

4. The array `A` shown below is used to represent the complete binary tree.

i	1	2	3	4	5	6
A[i]	23	15	9	6	11	2

Please answer the following three questions:
(1) [5 points] Draw the corresponding binary tree T.
(2) [5 points] Is T a max heap? Is T a min heap? Explain your reasons.
(3) [15 points] Perform the following three heap operations sequentially: `INSERT(18)`, `INSERT(27)`, `DELETE` on T. Draw the resultant tree after each operation.

5. (a) [5 points] Given an unsorted integer array of size n, does the binary search algorithm outperform the sequential search algorithm? Use the big-O notation to justify your answer.

(b) [5 points] Given an integer array `A` of size n, the following pseudo-code shows the quick-sort algorithm. Note that we assume that all array elements in `A` are distinct and the function `medium(A)` will return the value `x` in `A` such that the number of integers that are larger than `x` is equal to the number of integers that are smaller than `x`. Besides, we assume that the running time of the function `medium(A)` is $O(n)$. Derive the worst case running time of `quicksort(A)` in terms of big-O notation. (Note that you will get 0 points if you just give the answer directly.)

```
void quicksort(A: array) {
  if (length(A)==0)
    return;
  x = medium(A);
  S = { y | y∈A and y < x };
  L = { z | z∈A and z > x };
  quicksort(S);
  print x;
  quicksort(L);
}
```

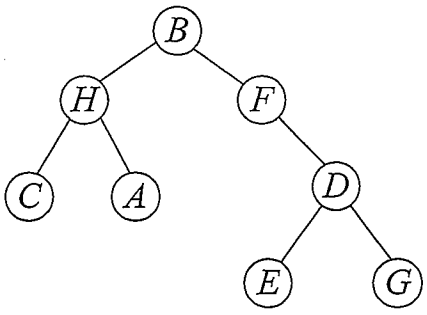
(c) [5 points] The following `enhanced_quicksort` algorithm written in a C-like pseudo-code tries to first split the array `A` into three partitions and then recursively sorts the arrays `S`, `M`, and `L`. Note that we carefully design two selection functions, `first_selection_function(A)` and `second_selection_function(A)`, to guarantee that `min(A)` < `x` < `y` < `max(A)`, where `min(A)` and `max(A)` denote the minimum element and the maximum element in array `A`, respectively. Moreover, we assume that the running time of each selection functions is $O(n)$. Please tell us whether the `enhanced_quicksort` algorithm is more efficient than the `quicksort` algorithm? Use the big-O notation to justify your answer.

```
void enhanced_quicksort(A: array) {
  if (length(A)==0)
    return;
  x = first_selection_function(A);
  y = second_selection_function(A);
  /* The above two selection functions together guarantee that
     min(A) < x < y < max(A).  */
  S = { a | a∈A and a < x };
  M = { b | b∈A and x < b < y };
  L = { c | c∈A and c > y };
  enhanced_quicksort(S);
  print x;
  enhanced_quicksort(M);
  print y;
  enhanced_quicksort(L);
}
```

6. (1) [5 points] Please convert the infix expression shown below into postfix form.

$$A \times (B / (C - D) + E) \times \times F - G$$

(2) [10 points] Tell us the results of preorder and postorder traversals for the following binary tree.



國立中山大學102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、乙組、戊組、電波領域聯合】　　題號：431005

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. (20%) (a) What is the amplifier configuration in Figure 1. (b) Explain why the R_S can improve the thermal stability of the amplifier. (c) Please derive R_i, R_{in}, A_{VO}, A_V, G_{VO}, G_V, R_o and R_{out} of the amplifier in Figure 1. (2%, 2%, 2%*8)

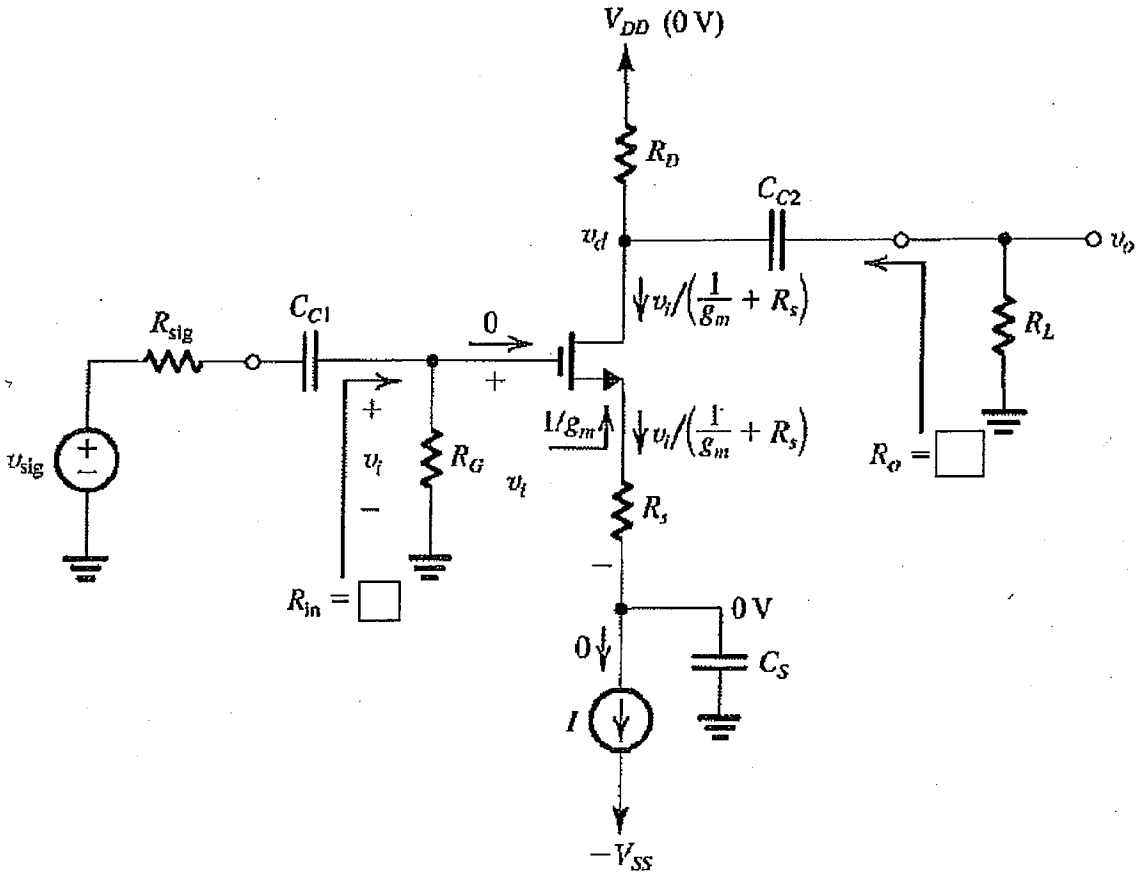


Figure 1

2. (20%) Figure 2 shows an op amp connected in the inverting configuration. The op amp has an open-loop gain $\mu = 10^4$, a differential input resistance $R_{id} = 100\text{k}\Omega$, and an output resistance $r_o = 1\text{k}\Omega$. Use the feedback method to find (a) the voltage gain V_o/V_s, (b) the input resistance R_{in}, and (c) the output resistance R_{out}. (7%, 7%, 6%)

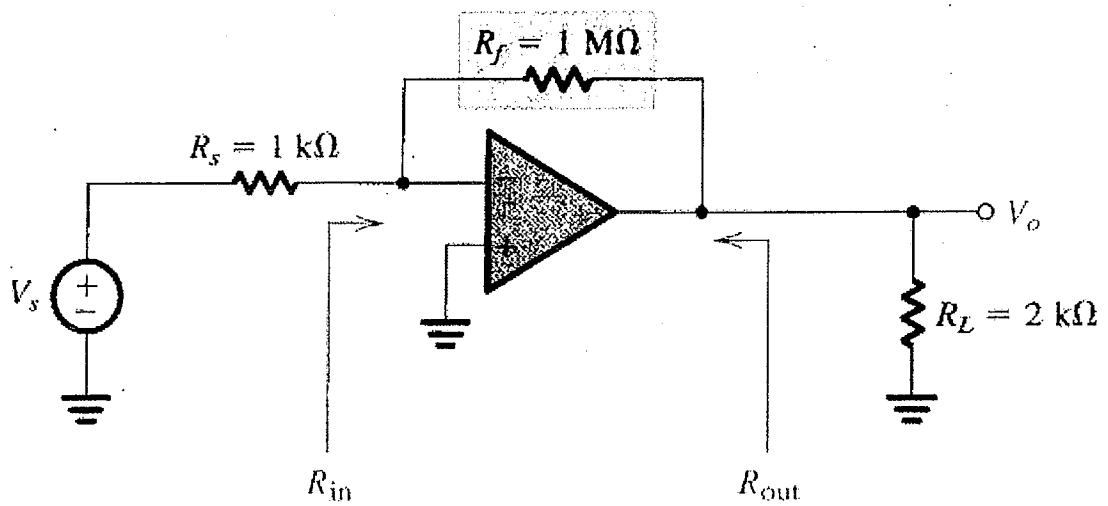


Figure 2.

3. (20%) (a) Draw an ENH mode NMOS (enhancement nMOSFET) and a DEP mode NMOS (depletion nMOSFET) respectively. Please explain what are the differences of (b) their fabrication processes and the differences between (c) their input characteristics I_{Ds}-V_{Gs} and (d) their output characteristics I_{Ds}-V_{Ds}, respectively. (5%, 5%, 5%, 5%)

4. (20%) (a) Using a simple (r_π and g_m) model for each of the two transistors Q_{18} and Q_{19} in Figure 4.a, find the small-signal resistance between A and A'. Where I_{C18} = 165 μA and I_{C19} = 16 μA. (b) Figure 4.b shows the circuit for determine the 741 op-amp output resistance when v_O is positive and Q_{14} is conducting most of the current. Using the resistance of the Q_{18} and Q_{19} network calculated in 4.(a) and neglecting the large output resistance of Q_{13A}, find R_o when Q_{14} is sourcing an output current of 5mA. (10%, 10%)

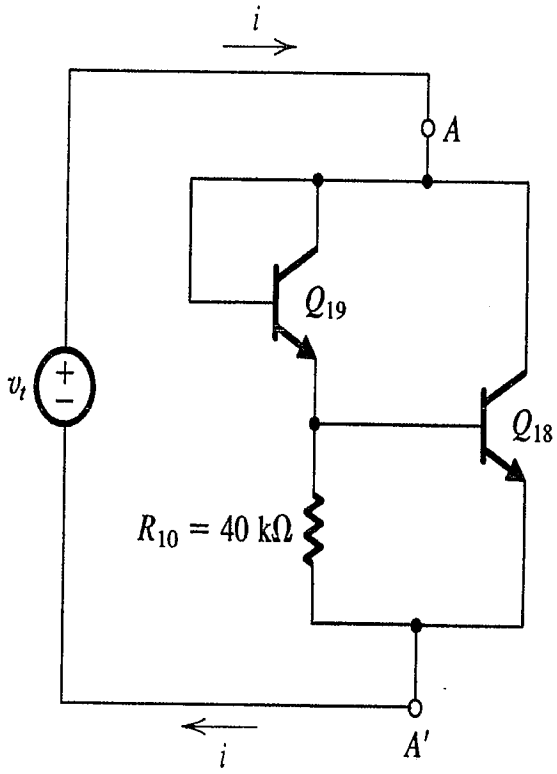


Figure 4.a

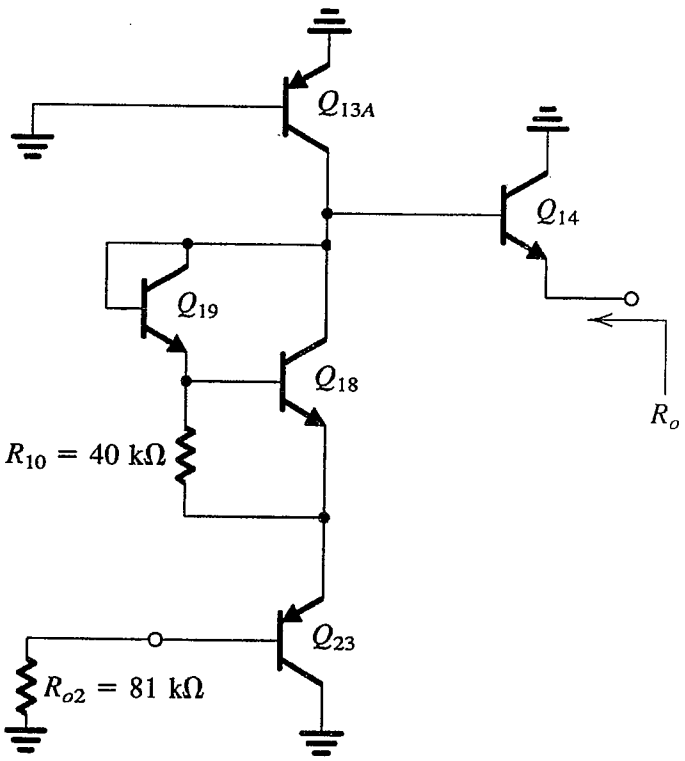


Figure 4.b

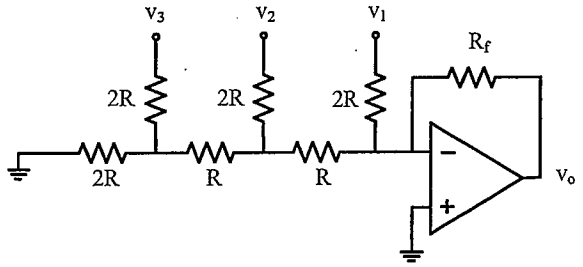
5. (20%) (a) Plot a Bridge full-wave rectifier and (b) explain the operation principle of it. Also, (c) please describe how to drive the PIV (peak inverse voltage) of the diodes used. (7%, 7%, 6%)

國立中山大學102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）　　

1. (10pt) A rechargeable battery is capable of delivering 100mA for 10 hours. How much charge can it release at that rate? If the terminal voltage is assumed as 3V, how much energy can the battery deliver?
2. (10pt) Find v_o of the following circuit. Assume ideal OP amplifier.

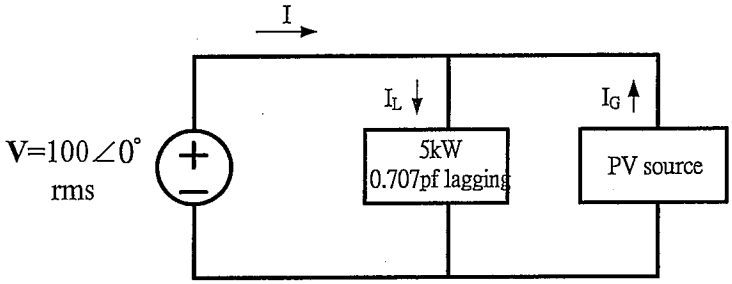


3. (10pt) A balanced Y-connected load is connected to the generator by a balanced transmission line with impedance of 0.1+j0.2Ω per phase. The load is rated at 500kW, 0.866 power factor lagging, $254V_{rms}$ phase voltage. Find line current and line voltage of the generator, respectively?

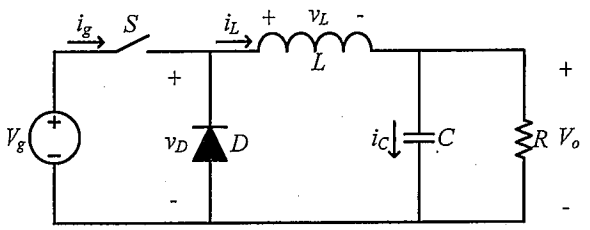
4. (10pt) Phase voltage and phase current of a load are given as $v(t)=141\cos\omega t$V, $i(t)=14\sin(\omega t+30^o)$ A. Find average power and reactive power of the load.

5. (10pt) If $i(t) = 1 + 5\cos(t+10°) + 3\cos(3t+35°)$ A flows into a resistor 10Ω, find
   (a) RMS current. (5pt)
   (b) Average power consumed by the resistor. (5pt)

6. (20pt) Assume the PV is a current source inverter to deliver 1kW average power to the system.
   (A)Calculate I. (5pt)
   (B)Calculate I_L. (5pt)
   (C)Calculate power factor. (5pt)
   (D)How to improve the power factor to 0.95. (5pt)



7. (30pt) A buck converter is given with the following parameters: Vg=20V, Vo=12V, the switching frequency of S is 10kHz, output power is 100W.
   1.Find minimum inductance L to keep the converter operated in continuous conduction mode.(10pt)
   2.Ripple current on the inductor. (10pt)
   3.Draw waveforms of both diode voltage and inductor current. (10pt)



國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：數位電路【電機系碩士班丙組選考、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）　　

[Problem 1] (20%) Short answer questions:

(a) Give one example to show that "the simplest expression of a Boolean function may not be unique". (4%)

(b) Give a general structure of a sequential circuit and use this structure to explain the differences of a sequential circuit from a combinational circuit (4%)

(c) What is a Mealy finite state machine? (2%) Give one design example of a Mealy finite state machine. Note that you need to give the function of this design and its state diagram. (5%)

(d) Give some waveforms to explain the meaning of the setup time and the hold time of a D flip-flop. (5%)

[Problem 2] (18%) Design a synchronously resettable positive edge-triggered finite state machine that has a one-bit input d and two outputs x and y. x should be 1 if d has been 0 for at least two cycles (not necessarily consecutively). y should be 1 if d has been 0 for at least three consecutive cycles. For example, the input sequence d=0101100011010 results in the output x=0011111111111 and the output y=0000000100000.

(a) Give Verilog/VHDL codes of a synchronously resettable positive edge-triggered flip-flop. (3%)

(b) Draw the state transition diagram and define each state clearly. (5%)

(c) Write RTL Verilog/VHDL codes to implement the finite state machine you designed in (b). (10%)

[Problem 3] (15%) 2-4-2-1 is a useful 4-bit binary code to represent decimal digits, as listed in Table 1. Design a combinational circuit F that can check if the decimal input encoded by 2-4-2-1 is a prime number, i.e., a positive integer that is greater than 1 and can be exactly divided by only 1 and itself. That is, the output F of the circuit equals 1 if and only if the decimal input is a prime number. You need to show the truth table of this circuit and design the two-level NAND-NAND network using the minimum number of logic gates and literals. Please note that the input code words (w, x, y, z) and their complements can be used directly as fan-in in the final logic diagram, and the unused input code words can be used as don't care conditions for logic simplification.

Table 1

Decimal digit	2-4-2-1 code
0	0000
1	0001
2	0010
3	0011
4	0100
5	1011
6	1100
7	1101
8	1110
9	1111

國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：數位電路【電機系碩士班丙組選考、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）　　

[Problem 4] (15%) Design an asynchronously resettable positive edge-triggered counter with the following repeated binary sequence: 0, 3, 1, 4, 7, 5, 2, 6. Note that the counter must have the parallel-load capability, i.e., the content of the counter can be arbitrarily specified via the circuit inputs.

(a) Draw the state transition diagram and define each state clearly. (5%)

(b) Write RTL Verilog/VHDL codes to implement the counter. (10%)

[Problem 5] (20%) Implement the following Boolean function

$F(w, x, y, z) = xy + w'xy' + w'x'z' + wx'y'z' + wx'yz.$

(a) by using only NOR and inverter gates. (5%)

(b) by using only AND and inverter gates. (5%)

(c) by using the simplest sum-of-products form (5%)

(d) by drawing the logic diagram using a multiplexer (5%)

Please note that for (a), (b) and (c) you only need to show the final Boolean function and how you derive the function.

[Problem 6] (12%) Memory related questions.

(a) What is RAM? (2%)

(b) What is ROM? (2%)

(c) Explain in detail how to write and read a memory, respectively. (3%)

(d) Give some waveforms to explain the meaning of the access time and the cycle time of a memory. (5%)

國立中山大學102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：431008

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

Property	Si	GaAs
Dielectric constant	11.9	13
Energy gap, E_g (eV)	1.12	1.43

1. A silicon sample is doped with 10^{16} donor atoms/cm^3 at room temperature (300K). The intrinsic carrier density in Si is 9.65×10^9 cm^{-3}.
   (a) Find the carrier concentrations. (10%)
   (b) Find the Fermi level. (10%)
   (Note: Sketch the band diagram and mark E_C, E_V, E_F and E_i; indicate clearly the location of the Fermi level with respect to intrinsic level.)

2. Consider a GaAs PIN diode
   (a) Calculate the value of N_D with an intrinsic region thickness of 20 μm, and a permitted ΔE of 10^5 V/m. ΔE is the change in electric field across the depletion region. (10%)
   (b) An electric field of 3.5×10^5 V/m is needed to reach the saturation region. Find the bias voltage. (10%)

3. Calculate the maximum width of surface depletion region for a metal-SiO_2-Si capacitor having $N_A = 3\times10^{16}$ cm^{-3}. (20%)

4. A solar cell under an illumination of 80 W/m^2 has a short circuit current I_{sc} of 40 mA and an open circuit output voltage V_{oc} of 0.55V. What are the short circuit current and open circuit voltages when the light intensity is halved? (20%)

5. Consider the p^+n junction of a uniformly doped silicon n-channel JFET has doping concentrations of $N_A = 10^{18}$ cm^{-3} and $N_D = 7\times10^{15}$ cm^{-3} at T = 300K. The metallurgical channel thickness is 0.8 μm. Determine the built-in potential barrier and the pinchoff voltage of the JFET. (20%)

國立中山大學102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【電機系碩士班丙組、己組】　　題號：431009

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

[Problem 1] Terminology Explanation (20%)
(a) Superscalar Processor (b) Pipeline Processing (c) Real Time Processing
(d) Delayed branch (e) Multi-core Processor

[Problem 2] (a) Describe the floating-point addition algorithm and hardware for IEEE 754 standard.(10%) (b)Design the adder architecture for adding two IEEE 754 floating-point numbers with the normalization form result. (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 64K words. The main memory size that is cacheable is 256M * 32 bits. Design the cache structure and show how the processor' s addresses are interpreted. (20%)

[Problem 4] Briefly describe what three techniques are possible for I/O operations. (10%)

[Problem 5] (a)Given the instruction architecture as follows. (20%)

Name	Format	Example						Comments
add	R	0	18	19	17	0	32	add $s1, $s2, $s3
sub	R	0	18	19	17	0	32	sub $s1, $s2, $s3
lw	I	35	18	17	100			lw $s1, 100($s2)
sw	I	43	18	17	100			sw $s1, 100($s2)
beq	I	4	17	18	25			beq $s1, $s2, 100
bne	I	5	17	18	25			bne $s1, $s2, 100
slt	R	0	18	19	17	0	42	slt $s1, $s2, $s3
j	J	2	2500					j 1000(see section 3.8)
jr	R	0	31	0	0	0	8	jr $ra
jal	J	3	2500					jal 1000(see section 3.8)
Field size		6 bits	5 bits	5 bits	5 bits	5 bits	6 bits	All MIPS instructions 32 bits
R-format	R	op	rs	rt	rd	shamt	funct	Arithmetic instructions format
I-format	I	op	rs	rt	address			Transfer, branch format
Addi	**I**	**8**	**rs**	**rt**	**imm16**			**addi $s1, $s2, imm16**

Transfer the C program block as follows to the machine code as you can.

```
for(i=0; i<10; i++)
  A[i]= A[i]+k;
```

(Assume: Start address of 32-bit integer array *A*--> 0x1000,
Start address of 32-bit integer variable *k* --> 0x1100 and
Start address of 32-bit integer variable *i* --> 0x1104)

(b) Suppose we have made the following measurements of average CPI for instructions:

Instruction	Average CPI
Arithmetic	1.0 clock cycles
Data transfer	1.4 clock cycles
Conditional branch	1.7 clock cycles
Jump	1.2 clock cycles

Compute the effective CPI for the machine code at(a) . (10%)

國立中山大學 102 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：431010

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

PROBLEM 1 (40%)

Given a system described by the following differential equation

$$\frac{d^2y}{dt^2}-5\frac{dy}{dt}+6y=\frac{du}{dt};\quad y(0)=1,\ \frac{dy(0)}{dt}=-1$$

where u is the control input and y is the output.

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

(b) (10%) Find the zero-input response $y(t)$.

(c) (10%) Choose, among the following types of control, ones that are likely to stabilize the system (**One or more answers may be correct. Answers without supporting explanation are not acceptable**) : (i) P control (ii) I control (iii) D control (iv) PID control (v) PD control (vi) PI control

(d) (10%) Choose, among the following types of control, ones that are likely to regulate the system output to a constant level 0.5 with zero steady state error (**One or more answers may be correct. Answers without supporting explanation are not acceptable**): (i) P control (ii) I control (iii) D control (iv) PID control (v) PD control (vi) PI control

PROBLEM 2 (30%)

An LCR circuit is shown in Fig. 1, with its control input to be u, and output $y = x_2$.

(a) (10%) Derive a state-space representation of this LCR circuit.

(b) (10%) Suppose $L = C = R = 1$ and $x_1(0) = x_2(0) = 1$. What is the output y in **steady state** if $u = \sin(t)$?

(c) (10%) Following 2(b), let the control be $u(t) = -k_1x_1(t) - k_2x_2(t)$. Choose the gains k_1 and k_2 such that the closed loop poles are –2 and –3.

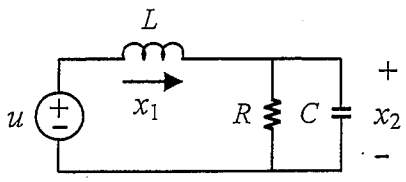


Fig. 1

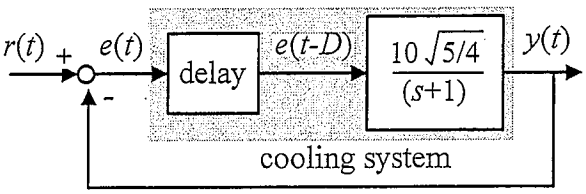


Fig. 2

PROBLEM 3 (20%)

Figure 2 shows a simple temperature control of a machine tool cooling system, where r is the setting temperature and y is the coolant temperature. There is a delay of D seconds present in the cooling system.

(a) (10%) Use **Laplace transform** to derive the transfer function from $e(t)$ to $e(t–D)$.

(b) (10%) Estimate the **maximum allowable delay** for the system to maintain at least 20 dB of gain margin, by using the approximation $\tan^{-1}\omega \approx \omega$, when $|\omega| << 1$.

PROBLEM 4 (10%)

After dozing off in the Monday morning class, your classmate asked you: "Integral control adds negative phase, thus decreasing the phase margin. Why would we ever want to use integral control?" Explain how you would answer him.

國立中山大學102學年度碩士暨碩士專班招生考試試題

科目名稱：電力工程【電機系碩士班丁組】　　題號：431011

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. A 230/115-V, 1-kVA transformer has been tested to determine its equivalent circuit. The results of the tests are shown below.

Short-circuit test	Open-circuit test
$Vsc = 21V$	$Voc = 230V$
$Isc = 9.57A$	$Ioc = 0.45A$
$Psc = 51.2W$	$Poc = 30W$

(a)Calculate the parameters and draw the equivalent circuit of this transformer referred to the low-voltage side of the transformer. (15%)
(b)Calculate the voltage regulation at rated conditions with Power Factor (PF) 1.0. (5%)

2. A power station consists of four 100-MVA, 69-kV, 0.9-PF lagging synchronous generators operating in parallel with identical speed droop characteristics. The governors on the generators' prime movers are adjusted to produce a 3-Hz drop from no load to full load. Three of these generators are each supplying a steady 75 MW at a frequency of 60 Hz, while the fourth generator handles all incremental load changes on system while maintaining the system's frequency at 60 Hz.
(a)The total system loads are 260 MW at a frequency of 60 Hz. Calculate the no-load frequencies of each generator. (10%)
(b)Calculate the new system frequency if the system load rises to 290 MW. (10%)

3. The fuel cost function in \$/h for four units of a plant are

$f_{g1} = 0.006P_{g1}^2 + 9.0P_{g1} + 345$　　$f_{g2} = 0.0048P_{g2}^2 + 6.0P_{g2} + 475$

$f_{g3} = 0.004P_{g3}^2 + 8.0P_{g3} + 625$　　$f_{g4} = 0.0034P_{g4}^2 + 10.0P_{g4} + 527$

Assume that all four units operate economically to meet the total plant load of 700MW, find the incremental cost of the plant and the required output of each unit (20%).

4. The following equations are the real power and reactive power injected into a bus:

$$P_i = \sum_{n=1}^{N} |Y_{in}V_iV_n| \cos(\theta_{in} + \delta_n - \delta_i), \quad Q_i = -\sum_{n=1}^{N} |Y_{in}V_iV_n| \sin(\theta_{in} + \delta_n - \delta_i).$$

Calculate the derivatives of $\frac{\partial P_i}{\partial \theta_i}$, $\frac{\partial P_i}{\partial \theta_j}$, $\frac{\partial P_i}{\partial V_i}$, $\frac{\partial P_i}{\partial V_j}$, $\frac{\partial Q_i}{\partial \theta_i}$, $\frac{\partial Q_i}{\partial \theta_j}$, $\frac{\partial Q_i}{\partial V_i}$ and $\frac{\partial Q_i}{\partial V_j}$ for Newton-Raphson Load Flow. (25%)

5. A three-phase, 60-Hz, 250-MVA, 13.8-kV, generating unit has an H constant of 4.0 p.u.-s. The mechanical power supplied by prime mover and electrical power output of the generator in p.u. are p_m and p_e, respectively. Initially, this unit is operating synchronously at $p_m = p_e = 2.0$ with power angle $\delta = 10^\circ$.
(a) Give the per-unit swing equation for this unit. (5%)
(b) Calculate the power angle 4 cycles after a short circuit causes $p_e = 0$.(10%)

國立中山大學102學年度碩士暨碩士專班招生考試試題

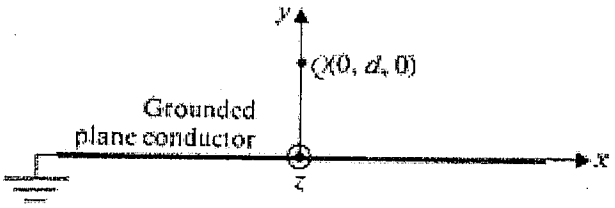
科目名稱：電磁學【電機系碩士班戊組、電波領域聯合】　　題號：431012

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

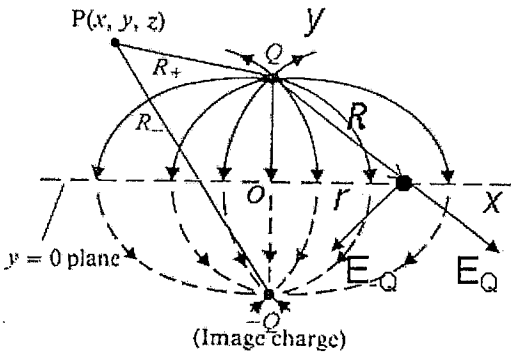
Problem 1

a. (10%) Using the Method of Image, write down the potential distribution, $V(x, y, z)$, for a point $P(x, y, z)$ in space, as shown in Figure (a), in terms of R_+ and R_-, as indicated in Figure (b). The dielectric constant of the space is ε_0.

b. (10%) Write the electric intensities ($Ex|_{y=0}$, $Ey|_{y=0}$, and $Ez|_{y=0}$) for a point on the ZX-plane in terms of d and R, or d and r, as indicated in (b).



(a) Physical arrangement.



(b) Image charge and field lines.

Figures (a) and (b) a single charge Q above a ground plane

Problem 2

A air-filled coaxial with dimensions as shown in the following figure:

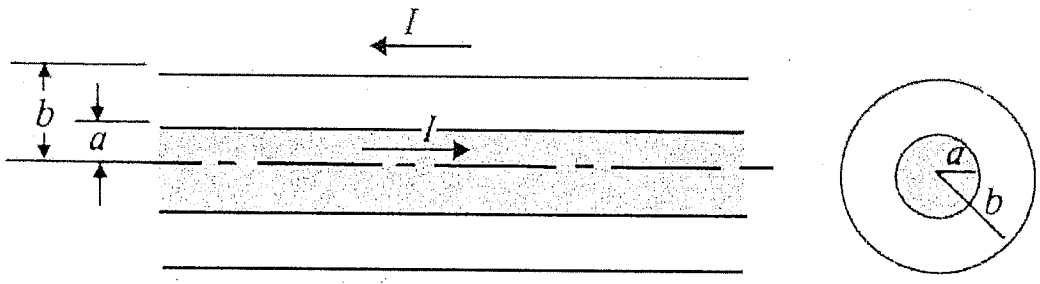


Figure (c) a coaxial transmission line with signal carrying conductor of radius a inside the surrounding ground of radius b.

The inductance per unit length is $L' = \frac{\Lambda'}{I} = \frac{\mu_0}{8\pi} + \frac{\mu_0}{2\pi}\ln\frac{b}{a}\left(\mathrm{H/m}\right)$. Here we have assumed that the current inside the signal-carrying conductor is uniformly distributed.And, the capacitance per unit length is $C' = \frac{2\pi\varepsilon_0 L}{\ln\left(\frac{b}{a}\right)}$ (F/m).

a. (5%) For the inductance, which term drops off at high frequencies? Why?

b. (5%) The characteristic impedance is defined as $Z_c = \sqrt{\frac{L'}{C'}}$, find out the characteristics impedance at high frequencies, and please indicate the unit for it.

Problem 3

a. (5%) The dielectric constant for Teflon is 2; it is a low one for a dielectric material. What is the dielectric constant for air?
b. (5%) What is the dielectric constant for a metal, for example, Copper?
c. (5%) Explain the difference between a dielectric and a conductor.
d. (5%) The relative permeability for Steel is 100, and is frequency dependent. What is the relative permeability for Copper?

Problem 4

(10%) Refer to the following figure and prove the law of Cosines, $C = \sqrt{A^2 + B^2 - 2AB\cos\alpha}$.

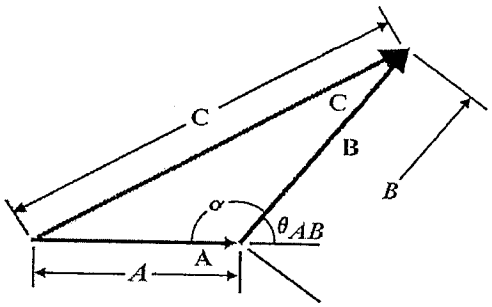


Figure (d) Illustrating example for Problem 4

Problem 5

(15%) A parallel polarized plane wave is obliquely incident from free-space onto a magnetic material with permittivity ε_0 and permeability $\mu_0\mu_r$. Find the reflection coefficient, transmission coefficient, and Brewster angle.

Problem 6

(15%) A 50 Ω transmission line is matched to a 10V AC source and feeds a load Z_L = 100 Ω. If the line is 2.3 λ long and has an attenuation constant α = 0.5 dB / λ. Find the powers that are delivered by the source, lost in the line, and delivered to the load.

Problem 7

(10%) For a rectangular waveguide that supports TE_{10} mode, explain why a narrow slot can be cut along the centerline of the broad wall of the rectangular waveguide without perturbing the propagation of the TE_{10} mode.