國立中山大學103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. (15%) Evaluate the following integral

$$\int_0^{\infty} \frac{\cos(ax) - \cos(bx)}{x^2} dx, \quad a \geq 0,\ b \geq 0$$

2. (15%) Define the Fourier transform of a signal $f(t)$ as $F(\omega) = \int_{-\infty}^{\infty} f(t)\mathrm{e}^{-j\omega t} dt$.

   (a) (7%) Compute the quantity A given below

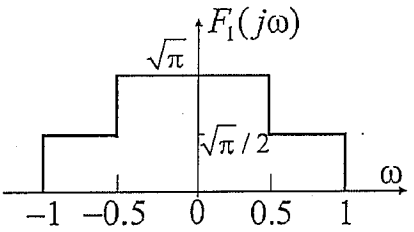
   $$A = \int_{-\infty}^{\infty} |f_1(t)|^2 dt,$$

   where the Fourier transform of $f_1(t)$ is given in the following figure (a).

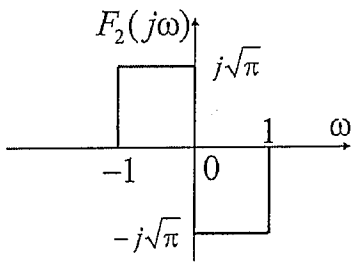
   (b) (8%) Compute the quantity B given below

   $$B = \frac{d}{dt} f_2(t)\Big|_{t=0},$$

   where the Fourier transform of $f_2(t)$ is given in the following figure (b).



(a)



(b)

3. (19%) 下面的問題共有三個子題，**(a)子題要清楚地寫出證明，(b)子題只要簡短扼要地回答提問即可，(c)子題除提出答案外、還需寫出答案背後的推導。**

Let A be any matrix in $\mathbb{R}^{m\times n}$. Then, since $\mathrm{rank}(A) = \dim(R(A))$, the dimension of range of A, and $R(A) = R(AA^T)$, we have the result $\mathrm{rank}(A) = \mathrm{rank}(AA^T)$. Therefore, when replacing A by its QR factorization, we get $\mathrm{rank}(A) = \mathrm{rank}(QRR^TQ^T)$.

(a) (6%) Please continue the argument to derive the result $\mathrm{rank}(A) = \mathrm{rank}(R)$.

（接下來前段是背景知識介紹，之後才是提問）In solving the linear equation $A\mathrm{x} = b$ for a given $b \in \mathbb{R}^m$, instead of using the elementary row operations (i.e. the Gauss eliminations) to manipulate the equation, we may also apply the QR factorization to the equation to get $QR\mathrm{x} = b$, which implies further $Q^TQR\mathrm{x} = Q^Tb$. Since $Q^TQ = I_n$, it gives $R\mathrm{x} = Q^Tb$. Thus, according to the result of (a), when all columns of A are linearly independent, the square matrix R is nonsingular and so the solution $\mathrm{x} = R^{-1}Q^Tb$ is obtained.
It seems that we may summarize the above argument as the following statement:

Given $A \in \mathbb{R}^{m\times n}$ and $b \in \mathbb{R}^m$, where all columns of A are assumed linearly independent, then solution to the equation $A\mathrm{x} = b$ can always be computed from $\mathrm{x} = R^{-1}Q^Tb$, where Q and R are matrices obtained from the QR factorization of A.

背面有題

However, the simple example $\begin{bmatrix}1\\0\end{bmatrix}\mathrm{x} = \begin{bmatrix}0\\1\end{bmatrix}$ shows that the summary is incorrect because, according to the summary, the solution is $\mathrm{x} = R^{-1}Q^Tb = (1)^{-1}\begin{bmatrix}1 & 0\end{bmatrix}\begin{bmatrix}0\\1\end{bmatrix} = 0$ and obviously it does not satisfy the original equation.

(b) (5%) What is the error (or are the errors) in the argument right before the summary to make it incorrect?

(c) (8%) What does the obtained solution $\mathrm{x} = R^{-1}Q^Tb$ mean? Give your answer necessary explanations.

4. (26%) 下面的問題共有四個子題，只要簡短扼要地回答提問即可，不須寫出答案背後的推導。

Let V be a vector space with $\dim(V) = n$ and an ordered basis $E := [\mathrm{x}_1, \cdots, \mathrm{x}_n]$. Let $F := [\mathrm{y}_1, \cdots, \mathrm{y}_n]$ be the ordered orthonormal basis generated from basis E by applying the Gram-Schmidt Orthogonalization Process. For any $\mathrm{v} \in V$, let $[\mathrm{v}]_E$ and $[\mathrm{v}]_F$ denote the coordinate vectors of v with respect to bases E and F, respectively. Let T denote the transition matrix from basis E to basis F. Let $L : V \mapsto V$, i.e. L is a linear operator mapping V into itself, and suppose that

$$L(\mathrm{x}_i) = \alpha_{i1}\mathrm{x}_1 + \alpha_{i2}\mathrm{x}_2 + \cdots + \alpha_{in}\mathrm{x}_n, \quad \text{for } i = 1, \cdots, n$$

Let's denote the matrix representation of L with respect to basis E by A.

(a) (6%) Write an equation to indicate the relationship between the two coordinate vectors $[L(\mathrm{v})]_E$ and $[\mathrm{v}]_F$.

(b) (7%) Obviously, matrix T relates to the two bases E and F. What conclusions about vectors in basis E and/or in basis F can be drawn if the matrix T is known to be diagonal?

(c) (6%) Suppose now that $V \in \mathbb{R}^n$ and denote $X := [\mathrm{x}_1, \cdots, \mathrm{x}_n]$. Let $X = QR$ be the QR factorization of matrix X. Is there any relationship between matrices T, Q and R? If yes, write an equation to describe such a relationship. If no, give a brief explanation for it.

(d) (7%) Under what conditions on α_{ij} for $i, j = 1, \cdots, n$ will matrix A be an upper-triangular one?

5. (25%) 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) (10%) Let $a_{21} = -a_{11}$, and $a_{12} = -a_{22}$. Suppose $a_{11} + a_{22} \neq 0$ and $u \equiv 0$. Find the solution of x_1 and x_2 for the initial conditions $x_1(0) = a_{22} + 1$, $x_2(0) = a_{11} - 1$.

(b) (4%) Suppose $a_{11} = 0$, $a_{12} = 1$, $a_{21} = 0$, $a_{22} = -2$, and $u(t) = k(2x_1(t) - x_2(t))$. Find the range of k such that the solution of x_1 and x_2 converges to zero for any initial condition.

(c) (5%) Suppose $a_{11} = 0$, $a_{12} = 1$, $a_{21} = 0$, $a_{22} = -2$, and $u(t) = k(2x_1(t) - x_2(t))$. Find the range of k such that the solution of x_1 and x_2 exhibits oscillatory behavior for any nonzero initial condition.

(d) (6%) For the values $a_{11} = -1$, $a_{12} = 1$, $a_{21} = -3$, $a_{22} = -1$, and $u(t) = 1 + \cos(2t)$, calculate the steady-state response of $y(t) = 2x_1(t) - x_2(t)$.

End of Examination

國立中山大學103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、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. (15%) Evaluate the following integral

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2. (15%) Define the Fourier transform of a signal $f(t)$ as $F(\omega) = \int_{-\infty}^{\infty} f(t)\mathrm{e}^{-j\omega t}dt$.

   (a) (7%) Compute the quantity A given below

   $$A = \int_{-\infty}^{\infty} |f_1(t)|^2 dt,$$

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   $$B = \frac{d}{dt} f_2(t)\Big|_{t=0},$$

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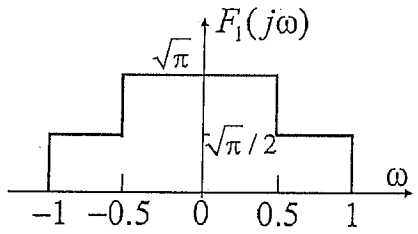
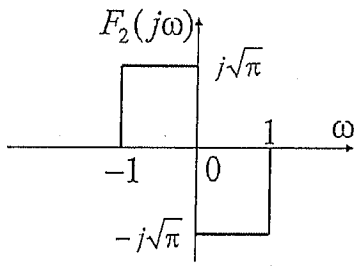


(a)



(b)

3. (11%) 下面的問題共有二個子題，**(a)子題要清楚地寫出證明，(b)子題只要簡短扼要地回答提問即可。**

Let A be any matrix in $\mathbb{R}^{m\times n}$. Then, since $\mathrm{rank}(A) = \dim(R(A))$, the dimension of range of A, and $R(A) = R(AA^T)$, we have the result $\mathrm{rank}(A) = \mathrm{rank}(AA^T)$. Therefore, when replacing A by its QR factorization, we get $\mathrm{rank}(A) = \mathrm{rank}(QRR^TQ^T)$.

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背面有題

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(b) (5%) What is the error (or are the errors) in the argument right before the summary to make it incorrect?

4. (14%) 下面的問題共有二個子題，**只要簡短扼要地回答提問即可**，不須寫出答案背後的推導。

Let V be a vector space with $\dim(V) = n$ and an ordered basis $E := [\mathrm{x}_1, \cdots, \mathrm{x}_n]$. Let $F := [\mathrm{y}_1, \cdots, \mathrm{y}_n]$ be the ordered orthonormal basis generated from basis E by applying the Gram-Schmidt Orthogonalization Process. For any $\mathrm{v} \in V$, let $[\mathrm{v}]_E$ and $[\mathrm{v}]_F$ denote the coordinate vectors of v with respect to bases E and F, respectively. Let T denote the transition matrix from basis E to basis F. Let $L : V \mapsto V$, i.e. L is a linear operator mapping V into itself, and suppose that

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Let's denote the matrix representation of L with respect to basis E by A.

(a) (6%) Write an equation to indicate the relationship between the two coordinate vectors $[L(\mathrm{v})]_E$ and $[\mathrm{v}]_F$.

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5. (25%) Consider the following system of differential equations:

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

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(c) (5%) Suppose $a_{11} = 0$, $a_{12} = 1$, $a_{21} = 0$, $a_{22} = -2$, and $u(t) = k(2x_1(t) - x_2(t))$. Find the range of k such that the solution of x_1 and x_2 exhibits oscillatory behavior for any nonzero initial condition.

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6. (15%) Let $\mathbf{F}(x,y,z) = (y+y^2z)\mathrm{i} + (x-z+2xyz)\mathrm{j} + (-y+xy^2)\mathrm{k}$

   (a) (3%) Verify that $\mathbf{F}$ is conservative.

   (b) (10%) Find a potential function $f(x,y,z)$ for $\mathbf{F}(x,y,z)$.

   (c) (2%) Find $\int_C \mathbf{F}\cdot d\mathbf{r}$, where C is the straight line going from the points (2,2,1) to the point (1, -1, 2).

7. (5%) Evaluate the following integral

$$\int_0^{\pi/2}\left(\int_y^{2y}\frac{\sin(x)}{x}dx\right)dy + \int_{\pi/2}^{\pi}\left(\int_y^{\pi}\frac{\sin(x)}{x}dx\right)dy$$

End of Examination

國立中山大學103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：431004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. (25%) Consider an ideal Si p-n diode with abrupt junction at T = 300 K (V_T = 25.9 mV) for which the doping concentrations are $N_A = 10^{15}$ cm^{-3} and $N_D = 10^{17}$ cm^{-3}. The cross-sectional area A = 100 μm^2. When this p-n diode is reverse biased with the reverse voltage V_R = 1 V, please calculate the depletion width of n-side W_n and p-side W_p, the charge stored on each side of the depletion region Q_J, the reverse saturation current I_S and the junction capacitance C_j. Let Si intrinsic concentration $n_i = 1.5 \times 10^{10}$ cm^{-3}, and Si permittivity $\varepsilon_{Si} = 11.7 \times 8.85 \times 10^{-14}$ F/cm. Diffusion length and diffusion coefficient of electron in p-side are L_n = 10 μm and D_n = 18 cm^2/s, respectively. Diffusion length and diffusion coefficient of hole in n-side are L_p = 5 μm and D_p = 10 cm^2/s, respectively. (W_n, W_p, Q_J, I_S, C_j: 5%*5)

2. (30%) Figure 1 shows a four-stage bipolar op-amp circuit. If all transistors are operating in the active region with the same β = 100, and V_T = 25mV. (1) Please perform an approximate dc analysis (assuming $|V_{BE}|$=0.7 V, and neglecting the Early effect) to calculate the quiescent power dissipation in this circuit. (2) What is the input common mode voltage range of this op-amp? (3) Calculate the voltage gain of the first stage and (4) the overall voltage gain. (5%, 5%, 5%, 15%)

3. (15%) Figure 2 shows a peak rectifier fed by a 100-Hz sinusoid having a peak value V_p = 120 V. The load resistance R = 20 kΩ. The output voltage shows a peak-to-peak ripple of 1.5V. Please calculate (1) the value of the capacitor C, (2) the fraction of the cycle during which the diode is conducting, (3) the average of the diode current. (5%, 5%, 5%)

4. (30%) Figure 3 shows the common-source amplifier with an ideal current source I = 0.4 mA, R_{sig} = 200 kΩ, R_G = 2 MΩ, $R_D = R_L$ = 20 kΩ, $C_1 = C_2 = C_3$ = 1 μF. The MOSFET has the device parameters: L = 0.2 μm, W = 2 μm, C_{ox} = 10 fF/μm^2, μ_n = 450 cm^2/V-s, r_o = 100 kΩ, C_{gs} = 3.2 fF, C_{gd} = 0.5 fF, C_{db} can be neglected, and the source terminal of MOSFET is connected to its body terminal. Please calculate (1) the transconductance g_m of the MOSFET, (2) the A_M, f_1, f_2, f_3 (let $f_1 < f_2 < f_3$) values of the overall low-frequency transfer function $\frac{V_o}{V_{sig}} = A_M(\frac{s}{s+2\pi f_1})(\frac{s}{s+2\pi f_2})(\frac{s}{s+2\pi f_3})$, (3) the upper 3-dB frequency f_H by using open-circuit time constants method. (5%, 5%*4, 5%)

背面有題

國立中山大學103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：431004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

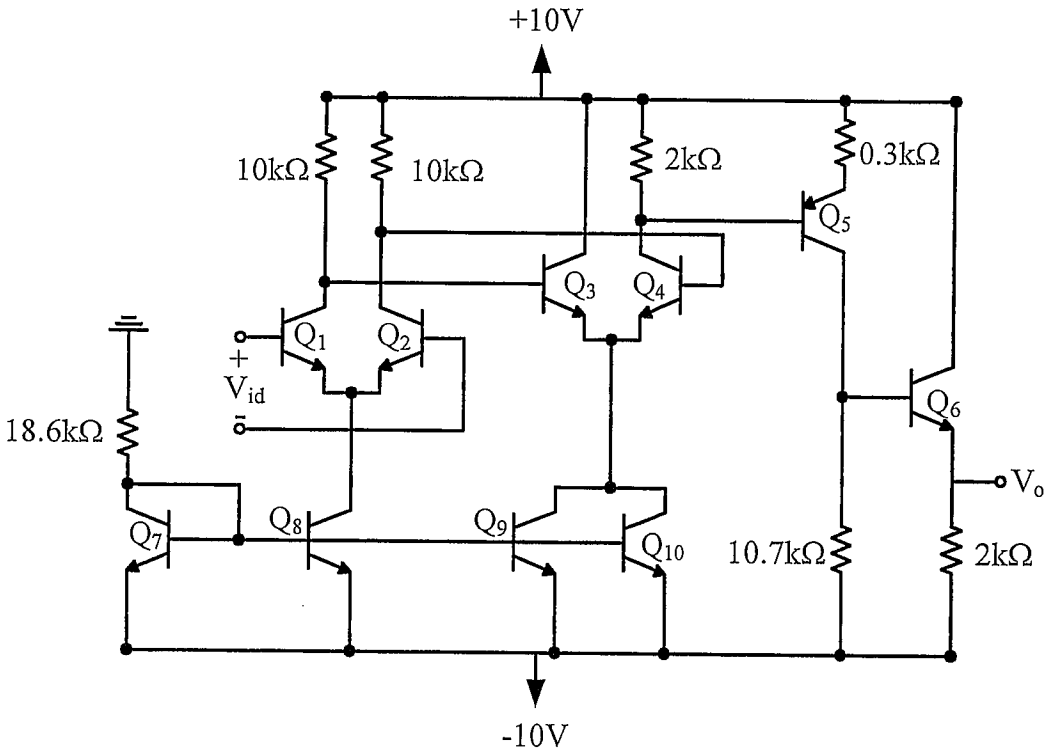

Figure 1.

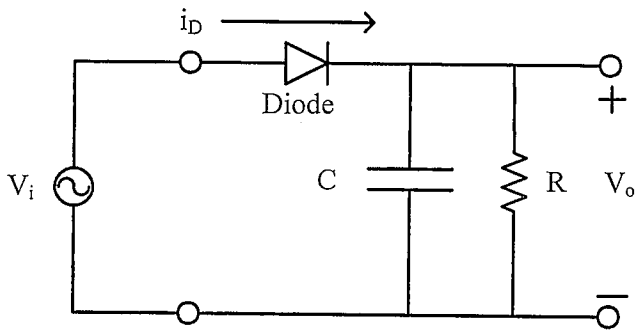

Figure 2.

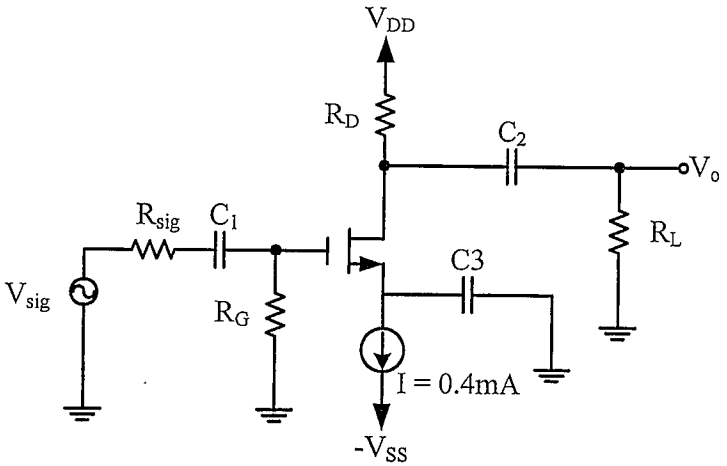

Figure 3.

國立中山大學103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）　　

1. (20pt) Find i(t) and v(t) for t>0 in Fig. 1, where u(t) is unit step function.

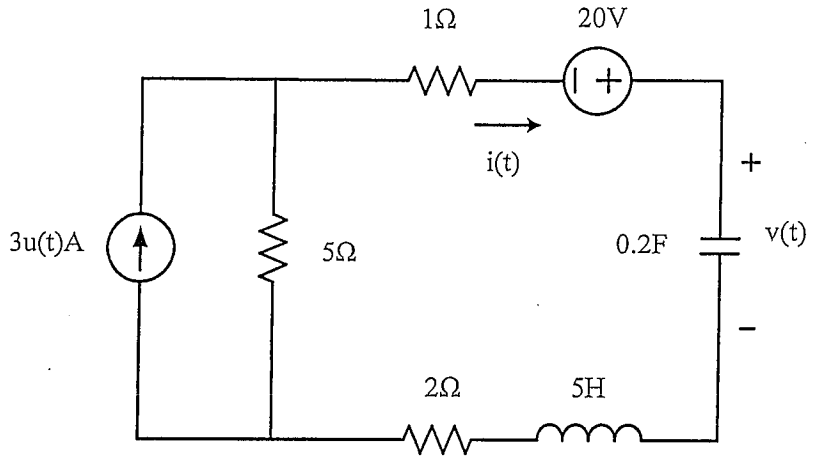

Fig. 1

2. (20pt) Voltage and current of a load are $v(t)=156\cos 314t$ V, $i(t)=10\sin(314t+30^o)+10\sin(942t+30^o)$ A, respectively. Find:
   (1) RMS current. (5pt)
   (2) Average power consumption. (5pt)
   (3) Power factor. (10pt)

3. (20pt) In Fig.2, assume the PV is a current source inverter to deliver 1kW at power factor 0.9 leading to the system.
   (A)Calculate apparent power supplied by the source.(10pt)
   (B)Calculate power factor of the source side. (10pt)

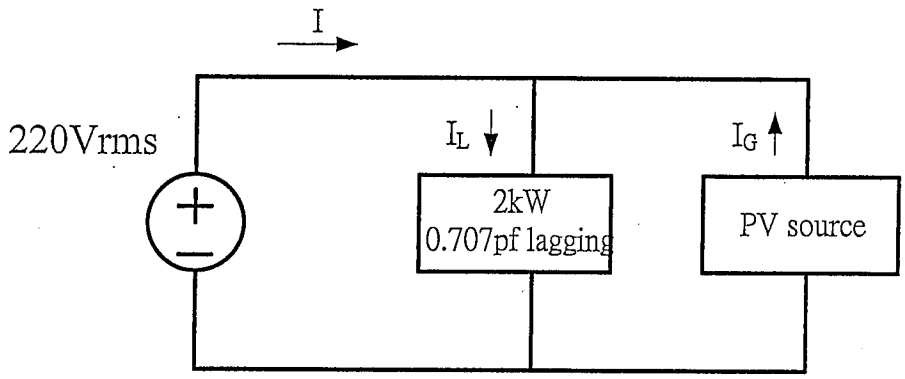

Fig. 2

4. (10pt) Find Vo and reactive power consumption on the mutual inductance in Fig. 3.

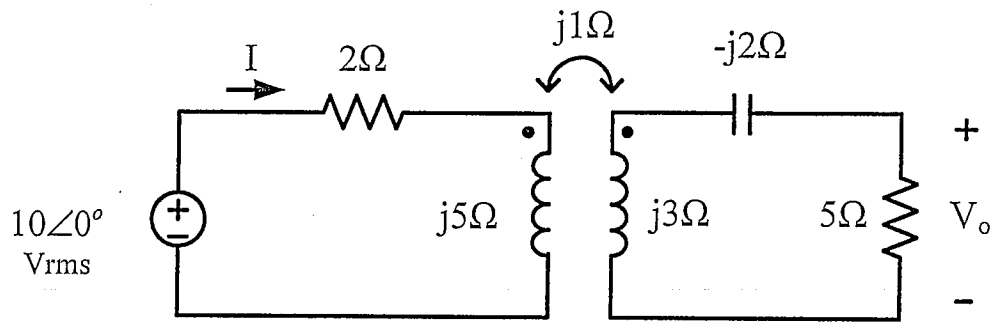

Fig. 3

背面有題

國立中山大學103學年度碩士暨碩士專班招生考試試題

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5. (10pt) Calculate power consumption on the resistor in Fig. 4. If one of the diodes, D, is open, re-calculate the power consumption.

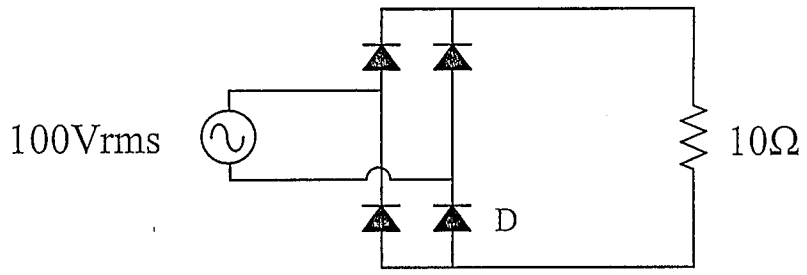

Fig. 4

6. (20pt) A buck converter in Fig. 5 is operated in the continuous conduction mode with the following parameters: Vg=20V, Vo=10V, L=200uH, switching frequency of S is 10kHz, output power is 20W.
   1. Find average inductor current.(5pt)
   2. Find average input current. (5pt)
   3. Find RMS capacitor current. (10pt)

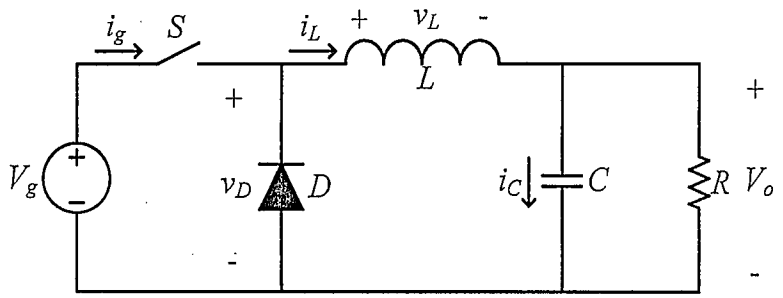

Fig. 5

國立中山大學103學年度碩士暨碩士專班招生考試試題

科目名稱：數位電路【電機系碩士班己組】　　題號：431006

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

(a) What are the features of a synchronous sequential circuit? (2%) Give one real application of a synchronous sequential circuit and explain the sequential features of this application. (3%)

(b) How to obtain the complement of a Boolean function? (2%) Give the complement of the Boolean function shown below. (2%)
$F(w, x, y, z) = xy + w'xz' + w'z' + x'yz.$

(c) Give the 2's complement of 10110100 (2%) Give the signed 2's complement of "-8" using a total of eight digital bits (2%)

(d) What is RAM? (2%) What is ROM? (2%)

(e) What are the three states of a three-state logic gate such as a tri-state buffer? (3%)

[Problem 2] (20%) Implement the following Boolean function
$F(w, x, y, z) = xy'z + x'y' + wxy'z' + yz + wx'.$

(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 3] (20%) 8-4-2-1 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 8-4-2-1 is an odd or even number. The output F of the circuit equals 1 if and only if the decimal input is an even number. Otherwise, F equals 0. 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	8-4-2-1 code
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

[Problem 4] (20%) What are two common storage elements in a sequential circuit? (4%) What are the differences between the operation conditions of these two elements? (4%) Give some waveforms to explain the meaning of the setup time and the hold time constraints in a synchronous sequential circuit. (6%) Give a general structure of a synchronous sequential circuit and use this structure to explain how the maximum operating frequency of a synchronous sequential circuit is determined. (3%) How can the maximum operating frequency be increased? (3%)

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國立中山大學103學年度碩士暨碩士專班招生考試試題

科目名稱：數位電路【電機系碩士班己組】　　題號：431006

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

[Problem 5] (20%) Design an asynchronously resettable positive edge-triggered finite state machine that has two one-bit input a and b, and one output y. y equals 1 if $a = b$ during any five cycles. Otherwise, y equals 0. For example,

a: 01101101001011001

b: 01001101101011000

y: 00000001000001110

(a) Give Verilog/VHDL codes of an asynchronously resettable positive edge-triggered flip-flop. (3%)
(b) Derive the state table for this finite state machine and define each state clearly (6%)
(c) Draw the state transition diagram (3%)
(d) Write RTL Verilog/VHDL codes to implement the finite state machine you designed. (8%)

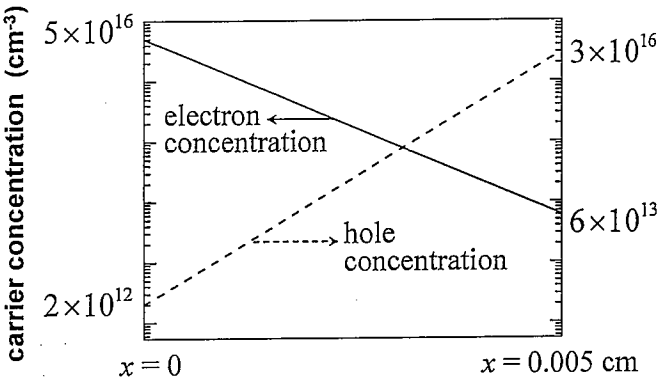
國立中山大學 103 學年度碩士暨碩士專班招生考試試題

科目名稱：半導體概論【電機系碩士班甲組】　　題號：431007

※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

Properties at 300K	Si	GaAs
Intrinsic carrier concentration (cm^{-3})	9.65×10^{9}	2.25×10^{6}
Electron mobility (cm^2/V-s)	1450	9200
Hole mobility (cm^2/V-s)	505	320

1. The electron and the hole concentrations in a silicon sample are shown below. The cross-sectional area of the sample is 2×10^{4} μm^2. Determine the total diffusion current versus distance x for $0 \le x \le 0.005$ cm.



(10%)

2. Silicon atoms, at a concentration of $8.2\times10^{15}\,cm^{-3}$, are added to GaAs. Assume that the silicon atoms act as fully ionized dopant atoms and that 10% of the concentration added replace gallium atoms and 90% replace arsenic atoms. $T = 300$K.
   (a) Determine the donor and acceptor concentrations. (5%)
   (b) What type of material would this yield? (5%)
   (c) Calculate the electron and hole concentrations. (5%)
   (d) Determine the position of the Fermi level with respect to the intrinsic Fermi level. (5%)

3. A silicon *p-n-p* BJT has impurity concentrations of 6×10^{18} cm^{-3}, $8\times10^{16}\,cm^{-3}$, and 9×10^{15} cm^{-3} in the emitter, base, and collector, respectively. The base width is 0.7 μm. The BJT is operated in the active mode with a $V_{BC} = 60$ V.
   (a) Calculate the maximum electric field at the collector-base junction. (5%)
   (b) Calculate the collector-base depletion capacitance per unit area. (5%)
   (c) Calculate the depletion layer width in base. (5%)
   (d) Explain the base width modulation and state its consequences. (5%)

4. Answer the following questions about MOS capacitor.
   (a) Explain the flat-band voltage. (5%)
   (b) Consider a n^+-polysilicon-SiO_2-Si capacitor with a *p*-type silicon substrate doped to $N_A = 10^{17}$ cm^{-3}, a silicon dioxide insulator with a thickness of 300 Å. The metal-semiconductor work function difference is -0.98 V. The fixed charge within the SiO_2-Si interface $Q_f/q = 4\times10^{10}\,cm^{-2}$. The dielectric constant of SiO_2 is 3.9. Calculate the flat-band voltage. (15%)

5. For DRAM operation, assume that we need a minimum of 10^5 electrons for the MOS storage capacitor. The capacitor has an area of 0.6 μm×0.6 μm on the wafer, an oxide thickness of 7 nm, and is fully charged to 3 V. What is the required minimum depth of a rectangular-trench capacitor? (20%)

6. Explain and compare the following terms.
   (a) positive photoresist and negative photoresist (5%)
   (b) evaporation and sputtering (5%)

國立中山大學 103 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】　　題號：431008

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

[Problem 1] (20%) Perform the following 4-bits 2's complement binary number operations. Which of the following operations generate *overflow*? Write down the correct results in binary form, and justify your answer by translating the two operands and results into decimal numbers.

(a) (10%) 0111 + 0111

(b) (10%) 1010 + 1100

[Problem 2] (20%) Write the decimal equivalents for the following two IEEE floating point numbers.

(a) (10%) 1 11000001 11010000000000000000000

(b) (10%) 1 00000000 01010000000000000000000

[Problem 3] (20%) A memory system with 512K bytes. Answer the following questions.

(a) (5%) How many address lines are required to address these 512K bytes, if a memory location can hold a word (4 bytes)?

(b) (5%) Draw this memory system by using (8Kx1)-byte chips and decoder.

(c) (5%) How many chips are required?

(d) (5%) How many input lines are required for the decoder to select these chips?

[Problem 4] (20%) A 2.0 GHz microprocessor runs a program of 1000 assembly instructions. Given the following assumptions: (i) all the instructions are 32-bit long and they all use immediate addressing mode; (ii) one memory location can accommodate one 32-bit instruction; (iii) an address or data bus cycle will take 2 CPU cycles; and (iv) address bus and data bus are both 16-bit wide. After an instruction is fetched from memory to instruction register, it requires 1 cycle for instruction decoding, 2 cycles for instruction execution, and 1 cycle for storing the result to register. Assume no instruction pipelining is employed, compute

(a) (5%) the number of CPU cycles required for executing the 1000 instructions.

(b) (5%) CPI (Cycles per Instruction).

(c) (5%) MIPS (Million Instructions per Second).

(d) (5%) CPU throughput (Programs per Second).

[Problem 5] (20%) Explain and compare the following terminology pairs.

(a) (5%) NAT vs DHCP

(b) (5%) DRAM vs SDRAM

(c) (5%) Direct-mapping cache vs Fully associate cache

(d) (5%) Parallelism vs Pipelining

PROBLEM 1 (40%)

A DC motor drives a machine-tool spindle and workpiece, and its dynamic equation is described by

$$J\frac{d\omega(t)}{dt} + B\omega(t) = KI(t-0.092) - T_L(t),$$

where ω is the angular velocity in units of rad/s, I is the input current, and T_L is the external torque generated by the cutting forces acting on the workpiece. There is an input delay of 0.092 s. The motor's torque constant K is found to be 0.1 by referring to the motor data sheet; but the moment of inertia J and the damping ratio B are unknown. Temporarily removing the workpiece (i.e., T_L=0), and doing the frequency response test by sweeping the frequency of the input current I, we can obtain the Bode plot of the transfer function between input current I and angular velocity ω, as displayed in Fig. 1.

a. (20%) Estimate the values of J and B.
b. (20%) Suppose that we employ a unity feedback to control the motor angular velocity and set the desired angular velocity to 100 rad/s, as shown in Fig. 2. Assume the load torque is constant T_L=0.1. Determine the phase margin of this feedback system. Also estimate the regulation error $e(t)$ in steady state.

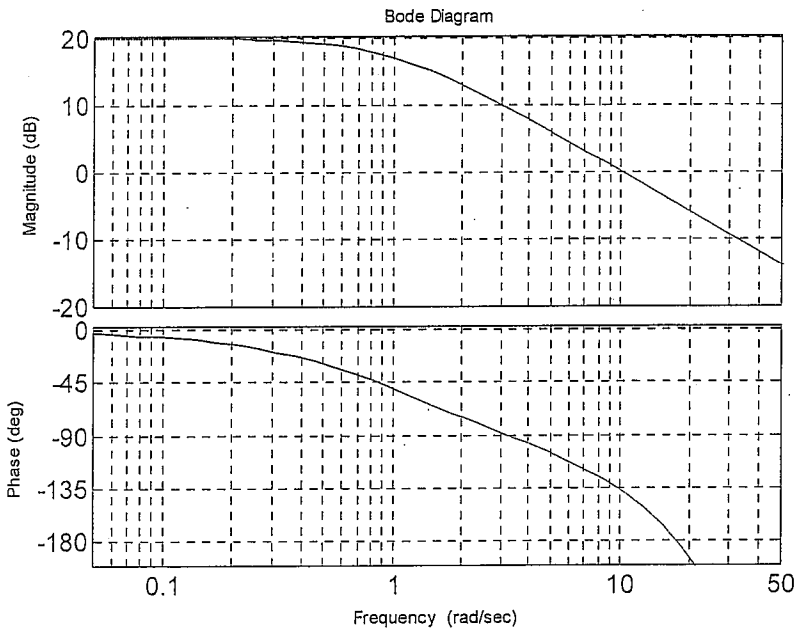


Fig. 1

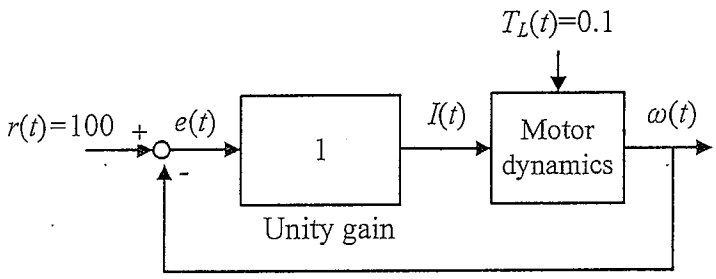


Fig.2

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PROBLEM 2 (15%)

Consider a system with the following unit step response y. Determine the poles and zeros of the system.

$$y(t) = \int_0^t (2 - e^{2\tau - 2t}) d\tau$$

PROBLEM 3 (15%)

Assume the operational amplifier in Fig. 3 is ideal. Show that the transfer function for the circuit can be written in the form

$$\frac{V_o(s)}{V_i(s)} = K_P + \frac{K_I}{s} + K_D s,$$

Determine the values of K_P, K_I, K_D.

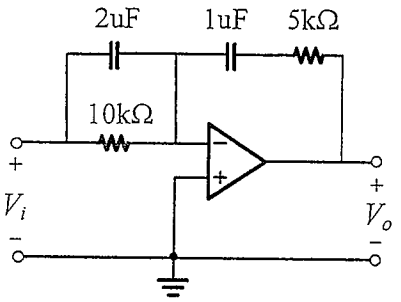

Fig. 3

PROBLEM 4 (30%)

Answer the questions about the feedback system in Fig.4.

a. (15%) Determine for the range of real number k the feedback system is stable
b. (15%) Assuming k=0, estimate the amplitude of the steady-state error when the reference input is $r(t) = \cos(2t)$.

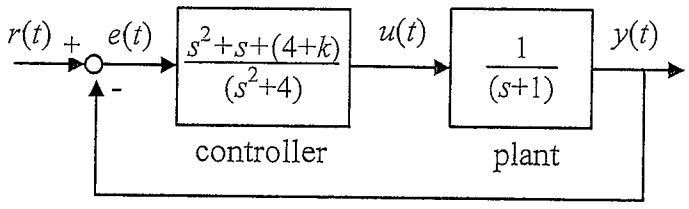

Fig. 4

國立中山大學 103 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：431010

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. Fig. 1 shows a simple loop rotating in a uniform magnetic field. It has the following characteristics (25%):

   $\omega_m = 377\ rad/s$, l=1.0 m,

   r=0.1 m, B=0.5 T to the right.

   Suppose that a 5 Ω resistor is connected as a load across the terminals of the loop.

   (a) Calculate the voltage induced in the rotating loop (e_{ind}) and the current flowing through the resistor. (10%)

   (b) Calculate the induced torque, electric power being generated and mechanical power being consumed by the loop. (15%)

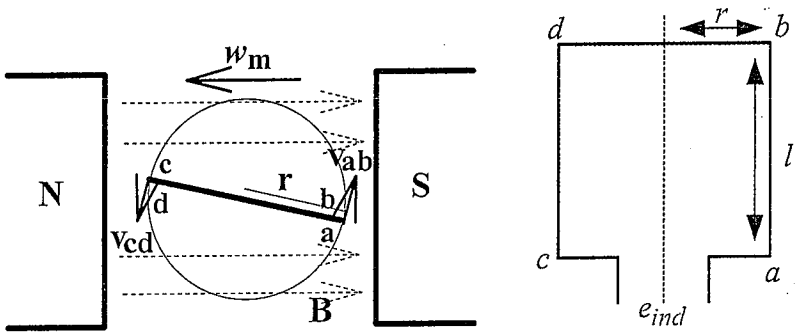

Fig. 1

2. Calculate the geometric mean radius of conductors shown in Fig. 2 in terms of the radius r of an individual strand. (10%)

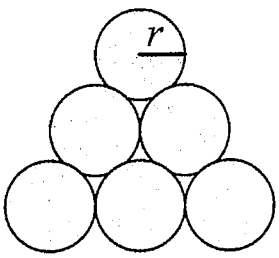

Fig. 2

3. Discuss the solution procedures for a power flow problem solved by a Netwon-Raphson technique. (including the procedure for swing bus, PV bus and PQ bus) (15%)

4. The impedance matrix ($\mathbf{Z}_{BUS}$) of a power system is

$$\mathbf{Z}_{BUS} = j\begin{bmatrix} 0.25 & 0.2 & 0.26 & 0.17 \\ 0.2 & 0.23 & 0.15 & 0.15 \\ 0.26 & 0.15 & 0.33 & 0.17 \\ 0.17 & 0.15 & 0.17 & 0.44 \end{bmatrix}$$

   Calculate the short-circuit current for a three-phase fault occurred in bus 2 and determine the bus voltages during the fault (15%).

5. Derive the solution for the following economic dispatch problem by Lagrangian multiplier (15%)

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$$\textit{Minimize} \quad C_T = \sum_{i=1}^{m} C_i(P_{Gi})$$

$$\textit{Subject to} \quad \sum_{i=1}^{m} P_{Gi} = P_D + P_{loss}$$

$$P_{Gi}^{\min} \le P_{Gi} \le P_{Gi}^{\max}$$

6. Assume that the impedances for zero-sequence, positive-sequence and negative-sequence networks are Z_0, Z_1 and Z_2, respectively. Derive the formulas for I_0, I_1, I_2 and I_a and draw the interconnected sequence networks for a single line-to-ground fault as shown in Fig. 3 (20%)

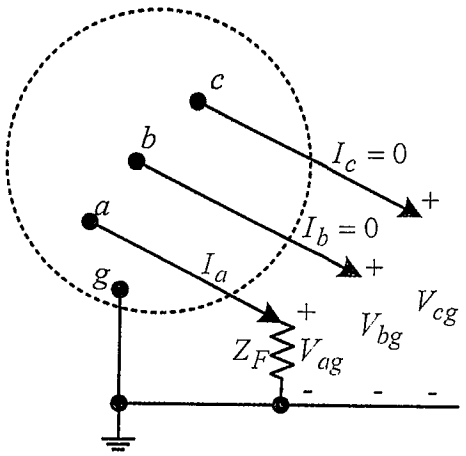

Fig. 3

國立中山大學103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：431011

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）　　

1. (20%)
   (a) (10%) Determine the self-inductance of a toroidal coil of N turns of wire wound on an air frame with mean radius r_1 and a circular cross section of radius a.
   (b) (10%) Obtain an approximate expression assuming $a \ll r_1$ in the part (a).

2. (20%) A finite line charge of length L carrying uniform line charge density ρ is coincident with the y-axis.
   (a) (10%) Determine V in the plane bisecting the line charge.
   (b) (10%) Determine $\mathbf{E}$ from ρ directly by applying Coulomb's law.

3. (30%) The field between the plates in Fig. P3 is a linearly polarized (in the y-direction) uniform plane wave traveling in the z-direction.
   (a) (10%) Assume that the plates are perfect electric conductors, then find the $\mathbf{E}$ and $\mathbf{H}$ field components between the plates. Neglect the edge effects of the finite plates.
   (b) (10%) Find the separation d between the plates that creates resonance.
   (c) (10%) Derive an expression for the Q of the cavity assuming a conductivity of σ for the plates. Neglect any radiation losses through the sides of the cavity.

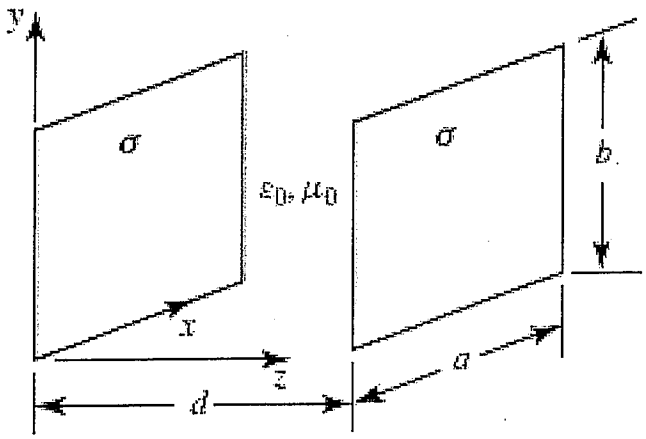

Fig.P3

4. (12%) A uniform plane wave $\mathbf{E}(x) = \mathbf{E}_0 e^{-\gamma x}$, $\mathbf{H}(x) = \mathbf{H}_0 e^{-\gamma x}$ with complex propagation constant γ propagating in a conductive medium with dielectric constant ε, conductivity σ and permeability μ. Use Maxwell's equations to show that

$$\eta \mathbf{H}_0 = \hat{\mathbf{a}}_x \times \mathbf{E}_0 \quad , \quad \mathbf{E}_0 = -\eta \hat{\mathbf{a}}_x \times \mathbf{H}_0 \quad , \quad \hat{\mathbf{a}}_x \cdot \mathbf{E}_0 = 0 \quad , \quad \hat{\mathbf{a}}_x \cdot \mathbf{H}_0 = 0$$

where η is the intrinsic impedance of the conductive medium.

5. (18%) Briefly answer the following questions:
   (a) (6%) What is dispersion? Under what situations will plane wave propagation suffer dispersion?
   (b) (6%) What is a Smith Chart? What are the situations a Smith Chart can be a very useful tool?
   (c) (6%) Describe the skin effect as detailed as possible.

國立中山大學103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：431012

※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) CISC (b) RISC (c) Reconfigurable Computing (d) Multi-core Processor

[Problem 2] Suppose we are considering a change to an instruction set. The base machine is a load-store machine. Measurements of the load-store machine showing the instruction mix and clock cycle counts per instructions are given in the following table:

Instruction Type	Frequency	Clock Cycle Count
ALU Operations	40%	1
Loads	20%	2
Stores	15%	2
Branches	25%	2

Let's assume that 25% of the ALU operations directly use a loaded operand that is not used again. We propose adding ALU instructions that have one source operand in memory. These new register-memory instructions have a clock cycle count of 2. Suppose that the extended instruction set increases the clock cycle count for branches by 1, but it does not affect the clock cycle time. Would this change improve CPU performance? Explain your answer. (20%)

[Problem 3] A set associative cache has a block size of four 64-bit words and a set size of 4. The cache can accommodate a total of 256K words. The main memory size that is cacheable is 512M * 64 bits. Design the cache structure and show how the processor's addresses are interpreted. (20%)

[Problem 4] Design an 8-bits multiplier in *Booth's Algorithm*. (15%)

[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+200. 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.

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 has not taken. How many cycles does this loop take to execute? (10%)

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. (15%)