國立中山大學九十三學年度碩士班招生考試試題

科目：工數（甲）（電機所 甲、丙選、丁、戊組）

1. (35%) In this problem, fill in the underlined blanks. Write you answers in the answer sheet. The detailed derivation is **NOT** required.

   Part I (15pts). Suppose $x(t)=t^2$, $-\pi<t<\pi$, and $x(t+2\pi)=x(t)$. Expand $x(t)$ in terms of Fourier series $x(t)=a_0+\sum_{k=1}^{\infty}[a_k\cos(k\omega_0 t)+b_k\sin(k\omega_0 t)]$, where ω_0 is the fundamental angular frequency.

   (a) What is a_k, $k=1,2,\cdots$? Answer ___(1)___.

   (b) What is b_k, $k=1,2,\cdots$? Answer ___(2)___.

   (c) Evaluate the series at $t=\pi$ to get $\sum_{k=1}^{\infty}\frac{1}{k^2}=\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{3^2}+\cdots=$ ___(3)___.

   Part II (10pts). The Fourier transform of $x(t)$ is defined as

   $X(j\omega)\triangleq\int_{-\infty}^{\infty}x(t)e^{-j\omega t}\,dt$. Suppose $x(t)=\begin{cases}1, & 0<t<\frac{1}{2}\\ 0, & t>\frac{1}{2}\end{cases}$ and $x(t)$ is odd.

   (a) What is $X(j\omega)$? ___(4)___.

   (b) Compute $\int_{-\infty}^{\infty}|X(j\omega)|^2\,d\omega=$ ___(5)___.

   Part III (10pts). Let field $\vec{A}=\vec{a}_r r^5$ exist in a ball of radius 1, where $\vec{r}=\vec{a}_x x+\vec{a}_y y+\vec{a}_z z$ is the position vector, $r=|\vec{r}|$, and $\vec{a}_r$ is the unit vector in $\vec{r}$ direction.

   (a) What is the volume integral $\int_V\nabla\cdot\vec{A}\,dv$ over the ball of unit radius? ___(6)___.

   (b) What is the surface integral $\int\vec{A}\cdot d\vec{s}$ over the surface of the top-half hemisphere of the ball of unit radius? ___(7)___.

2. (15%) Let $L: V\to W$ be a one-to-one and onto linear transformation between vector spaces V and W with $\dim(V)=r=\dim(W)$.
   Show that: if the set $\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ is a basis for V, then the set $\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ is a basis for W.

3. (15%) Given $A=\begin{bmatrix}1 & 0 & 2 & -2\\ 0 & 1 & -1 & 3\\ -1 & 1 & -3 & 5\end{bmatrix}$ and let its column space be denoted by $R(A)$.

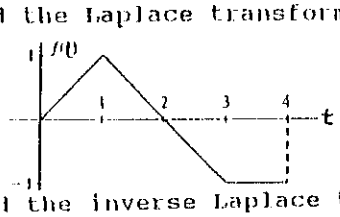
   (a) (6%) What is $R(A)^{\perp}$, the orthogonal complement of $R(A)$?

   (b) (9%) What is the projection matrix that will orthogonally project any vector $\mathbf{b}\in\mathbb{R}^3$ onto $R(A)^{\perp}$?

4. (15%) Find the general solution of the following differential equation :

   $$(-xy\ \sin x + 2y\ \cos x)dx + (2x\ \cos x)dy = 0$$

5. (10%) (a) Find the Laplace transform of the following function :



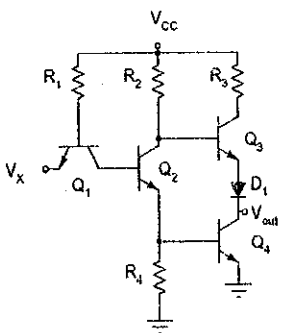
   (10%) (b) Find the inverse Laplace transform of the following function :

   $$\frac{s+12}{s^2+10s+35}$$

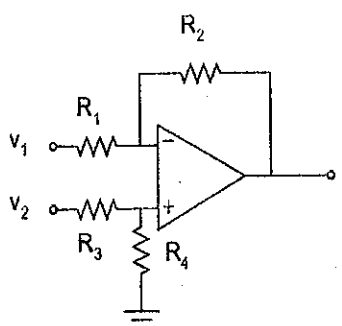
1. The TTL circuit has parameters : $V_{CC} = 5$ V, $R_1 = 6$ kΩ, $R_2 = 2$ kΩ, $R_3 = 800$ Ω, $R_4 = 1.5$ kΩ, $\beta_F = 25$ and $\beta_R = 0.1$. (20%)

   (a) Determine the volatges at each node and currents in each transistor (i_B , and i_C,) for V_X= logic 0.

   (b) Repeat for V_X = logic 1.



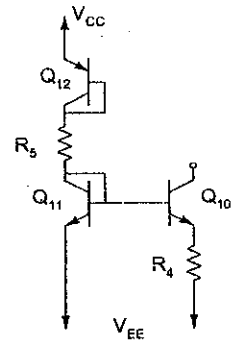
2. Consider the difference amplifier shown. Let $R_1 = R_3 = 10k\Omega$ and $R_2 = R_4 = 1M\Omega$. If the op amp has $V_{os} = 2mV$, $I_B = 0.3\mu A$, and $I_{os} = 50nA$, find the worst case (largest) dc offset voltage at the output. (20%)



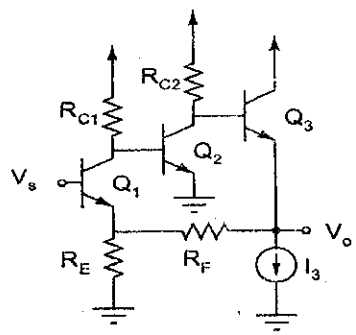
3. For the bias circuit shown, the transistors have the same parameter : $I_S = 10^{-14}A$. Also we have R_5=40kΩ, R_4=5kΩ, V_{CC}=15V, and V_{EE}=-15V. Calculate : (20%)

   (a) the reference current through R_{ref}.

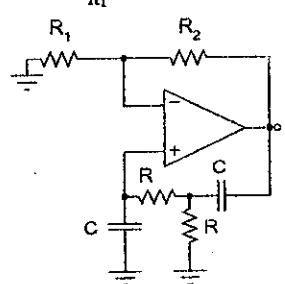
   (b) the collector current I_{C10}.



4. For the series-shunt feedback amplifier shown, determine A, β, R_{in}, and R_{out}. The transistors have h_{fe}=100 with Q_1 biased at 1mA, Q_2 at 2mA, and Q_3 at 5mA. The circuit paremeters are : R_E= 50Ω, R_F=950Ω, R_{C1}=1kΩ, R_{C2}=0.5kΩ. (20%)



5. For the oscillator circuit shown, determine the oscillating frequency and the ratio of $\frac{R_2}{R_1}$ for oscillation. (20%)



國立中山大學九十三學年度碩士班招生考試試題

科目：半導體概論 【電機工程學系碩士班 甲組】

1) In a nonuniform n-type doped semiconductor, assume the doping profile is linear increasing, i.e. dn/dx>0, under thermal equilibrium. Choose and explain the corrective answer (a) $dE_C/dx>0$, (b) $dE_C/dx<0$, (c) $dE_C/dx=0$, (d) $dE_f/dx>0$, (e) $dE_i/dx>0$, (f) $dE_f/dx=0$,(g) none of above (10%)

2) Choose and explain the corrective answer.In the energy band diagrams, for a Zinc-rich ZnSe semiconductor, the Fermi level, E_F is located at (a) toward to E_C above E_i , (b) toward to E_V below E_i , (c) closer to the middle gap, E_i (d) none of above . Where E_i is the position at middle gap. (10%)

3) Describe and explain : how to distinguish the GaAs and Si wafer" ? (20%)

4) Under a special condition, the Boron doped Si semiconductor, $Na=10^{15}$ cm^{-3} shows an intrinsic property. What condition can match above description?. (Boron : ionization energy=0.045 eV, $m_p^*=0.56\ m_O$; $m_n^*=1.08\ m_O$; Eg=1.1 eV; and $N_C=2.8\times10^{19}\ cm^{-3}$, $N_V=1.04\times10^{19}\ cm^{-3}$ at 300 k) (10%)

5) A silicon pn junction diode at T=300 K has the following parameters: $Nd=8\times10^{15}\ cm^{-3}$, $Na=2\times10^{15}\ cm^{-3}$, $Dn=25\ cm^2/s$, $Dp=10\ cm^2/s$, $\tau_{no}=5\times10^{-7}$ s and $\tau_{po}=10^{-7}$ s. The cross section area is $A=10^{-3}\ cm^{-2}$. The diode is forward biased at Va=5.0 V. Determine the ratio of I_{rec} to the ideal diffusion current. (I_{rec} = forward-biased recombination current.)(10%)

6) (a)Describe and explain "the type of junction between n-type Silicon and aluminum", and (b) what is the minimum n-type doping concentration required to obtain an "Ohmic contact ". (20%)
(For Si; electron affinity = 4.01 eV; Work function: aluminum = 4.28 eV)

7) Comparison of the Schottky barrier diode and the pn junction diode (10%)

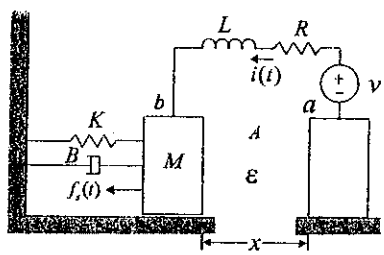
8) Describe and explain : the conductivity as a function of inverse temperature for a n-type Si when $Nd=10^{15}\ cm^{-3}$ (10%)

國立中山大學九十三學年度碩士班招生考試試題

科目：控制系統 【電機工程學系碩士班 乙組】

1. The electromechanical system shown below represents a simplified model of a capacitor microphone. The system consists in part of a parallel plate capacitor connected into an electric circuit. Capacitor plate a is rigidly fastened to the microphone frame. Sound waves pass through the mouthpiece and exert a force $f_s(t)$ on plate b, which has mass M and is connected to the frame by a set of springs and dampers. The capacitance C is a function of the distance x between the plates, i.e, $C(x) = \epsilon A/x$, where ϵ denotes the dielectric constant of the material between the plates, and A is the surface area of the plate. The charge q and the voltage $e(t)$ across the plates are related by $q(t) = C(x)e(t)$. Note also that $i(t) = \dot{q}(t)$. The electric field in turn produces the following force f_e on the movable plate that **opposes** its motion (i.e., opposes the direction of its velocity):

$$f_e = \frac{q^2}{2\epsilon A}.$$



(a)(10%) Write differential equations that describe the operation of this system.

(b)(10%) Assume the above system has the following dynamic equations:

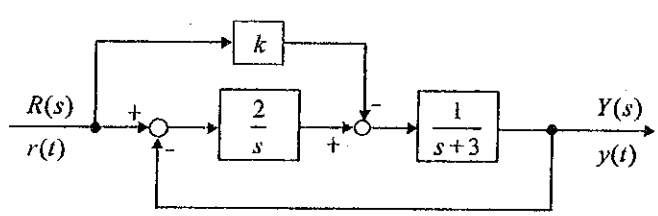
$$\begin{aligned} M\ddot{x} + B\dot{x}x + kx + \frac{q}{\epsilon A} &= f_s(t) \\ L\dot{q} + R\ddot{q} + \frac{qx}{\epsilon A} &= v \end{aligned} \tag{1}$$

Suppose that the input signal is v, find a linearized model (by assuming $x_1 = x$, $x_2 = \dot{x}$, $x_3 = q$, $x_4 = \dot{q}$) of (1) at the origin.

2.(17%) The block diagram of a control system is shown below. Compute the value of k to minimize the index function

$$I = \int_0^\infty e^2(t)dt,$$

where $e(t) = r(t) - y(t)$ is the tracking error due to a step input $r(t) = Au_s(t)$, A is a constant.



3. Given a characteristic equation of a control system as

$$s^3 + \alpha s^2 + ks + k = 0, \qquad -\infty < k < \infty$$

We first assume $\alpha = 12$. Find the

(a)(4%) open loop poles and zeros,

(b)(2%) intersect of the asymptotes (Centroid),

(c)(4%) angles of asymptotes,

(d)(5%) breakaway points, then

(e)(5%) use the previous information, construct the Root Loci for $-\infty < k < \infty$.

(f)(5%) Now suppose that α is a variable, determine the value of α so that there is only one nonzero breakaway point on the entire root loci for $\infty < k < \infty$. Construct the root loci.

4. Consider a control system with the loop transfer function

$$L(s) = \frac{K}{(s+2)(s^2+4)}, \qquad -\infty \le K \le \infty$$

(a)(8%) Sketch the Nyquist Plot of this system for $K > 0$.

(b)(6%) Using Nyquist criterion, determine the range of $K(> 0)$ such that the closed-loop system is stable. If the system is unstable due to the range of K, find the number of closed-loop poles in the right-half of $s-$plane.

(c)(6%) Using Nyquist criterion and the Nyquist plot of $K > 0$, determine the range of $K(< 0)$ such that the closed-loop system is stable. If the system is unstable due to the range of K, find the number of closed-loop poles in the right-half of $s-$plane.

5. Given a controllable and observable dynamic system in the form of

$$\begin{aligned} \dot{\mathbf{x}}(t) &= \mathbf{A}\mathbf{x}(t) + \mathbf{B}\mathbf{u}(t) \\ \mathbf{y}(t) &= \mathbf{C}\mathbf{x}(t) \end{aligned} \tag{2}$$

Suppose that $\mathbf{P} \in R^{n\times n}$ is a nonsingular matrix which transform (2) into

$$\begin{aligned} \dot{\mathbf{z}}(t) &= \bar{\mathbf{A}}\mathbf{z}(t) + \bar{\mathbf{B}}\mathbf{u}(t) \\ \mathbf{y}(t) &= \bar{\mathbf{C}}\mathbf{z}(t) \end{aligned} \tag{3}$$

through the transformation $\mathbf{z}(t) = \mathbf{P}\mathbf{x}(t)$.

(a)(4%) Are the characteristic equation of (3) the same as that of (2)? Prove it if you think they have the same characteristic equation.

(b)(4%) Are the transfer function of (3) the same as that of (2)? Prove it if you think they have the same transfer function.

(c)(10%) Prove that (3) is still controllable and observable.

國立中山大學九十三學年度碩士班招生考試試題

科目：工數（乙）（電機所乙組）

1. (25%) In this problem, fill in the underlined blanks. Write you answers in the answer sheet. The detailed derivation is **NOT** required.

   Part I (15pts). Suppose $x(t)=t^2$, $-\pi<t<\pi$, and $x(t+2\pi)=x(t)$. Expand $x(t)$ in terms of Fourier series $x(t)=a_0+\sum_{k=1}^{\infty}[a_k\cos(k\omega_0 t)+b_k\sin(k\omega_0 t)]$, where ω_0 is the fundamental angular frequency.

   (a) What is a_k, $k=1,2,\cdots$? Answer ___(1)___.

   (b) What is b_k, $k=1,2,\cdots$? Answer ___(2)___.

   (c) Evaluate the series at $t=\pi$ to get $\sum_{k=1}^{\infty}\frac{1}{k^2}=\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{3^2}+\cdots=$ ___(3)___.

   Part II (10pts). The Fourier transform of $x(t)$ is defined as

   $$X(j\omega)\triangleq\int_{-\infty}^{\infty}x(t)e^{-j\omega t}\,dt.$$ Suppose $x(t)=\begin{cases}1, & 0<t<\frac{1}{2}\\ 0, & t>\frac{1}{2}\end{cases}$ and $x(t)$ is odd.

   (a) What is $X(j\omega)$? ___(4)___.

   (b) Compute $\int_{-\infty}^{\infty}|X(j\omega)|^2\,d\omega=$ ___(5)___.

2. (25%) Let V and W be vector spaces with $\dim(V)=r=\dim(W)$ and let L be a *linear* mapping from V to W, i.e. $L: V\to W$ is *linear*. Let $\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ be a set of vectors in V with the corresponding image set $\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ lying in W. In each of the following questions, please first answer the question then prove the statement based on your answer.

   (a) Under what condition (or conditions) of L will the statement "if the set $\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ is linearly independent, then the set $\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ is linearly independent" hold?

   (b) Under what condition (or conditions) of L will the statement "if the set $\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ is linearly independent, then the set $\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ is linearly independent" hold?

   (c) Suppose the condition (or conditions) proposed in (a) hold. Under what extra condition (or conditions) of L will the statement "if the set $\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ is a basis for V, then the set $\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ is a basis for W" hold?

   (d) Suppose the condition (or conditions) proposed in (b) hold. Under what extra condition (or conditions) of L will the statement "if the set $\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ is a basis for W, then the set $\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ is a basis for V" hold?

   Now, let's denote $E:=\{\mathbf{x}_1,\cdots,\mathbf{x}_r\}$ and $F:=\{\mathbf{y}_1,\cdots,\mathbf{y}_r\}$ as two bases for V and denote $G:=\{L(\mathbf{x}_1),\cdots,L(\mathbf{x}_r)\}$ and $H:=\{L(\mathbf{y}_1),\cdots,L(\mathbf{y}_r)\}$ as two bases for W. Let P be the transition matrix from basis E to basis F and let Q be the transition matrix from basis G to basis H. Denote A as the matrix representation of L with respect to bases E and G, and denote the matrix representation of L with respect to bases F and H by B. Please answer the next question without giving any proof.

   (e) What are A and B, respectively, and what is the relationship between P and Q?

3. (15%) Let $A\in\mathbb{C}^{n\times n}$. Show that:

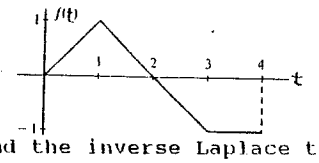
   (a) (7%) if $\|A\mathbf{x}\|_2=\|\mathbf{x}\|_2$ for all $\mathbf{x}\in\mathbb{C}^n$ then $\langle A\mathbf{x},A\mathbf{y}\rangle=\langle\mathbf{x},\mathbf{y}\rangle$ for all $\mathbf{x},\mathbf{y}\in\mathbb{C}^n$.

   (b) (8%) A is a unitary matrix if and only if $\|Ax\|_2=\|x\|_2$.

4. (15%) Find the general solution of the following differential equation :

   $$(-xy\sin x+2y\cos x)dx+(2x\cos x)dy=0$$

5. (10%) (a) Find the Laplace transform of the following function :



   (10%) (b) Find the inverse Laplace transform of the function : $\dfrac{s+12}{s^2+10s+35}$

1. (10%) Given a postfix expression as followed (where % means the remainder computation operator),
   20 5 3 + 6 * 8 3 − % 1 + /
   show its evaluation steps (also show the stack of buffered values during execution).

2. (10%) Given a linked list of values, we want to get a new list of values that has the same set of values in a reverse order. Write one such algorithm ***reverse(L)***.

3. (20%) In an arbitrary binary search tree of n values, we want to perform ***lookup(key,BS_tree)*** to search an element in the tree that matches *key* value.
   (a) (5%) What is its best case computation time complexity? What the binary search tree will look like?
   (b) (5%) What is its worst case computation time complexity? What the binary search tree will look like?
   Note: Use big O notation O(f(n)) to specify computation time complexity.
   (c) (10%) Write an algorithm for ***delete(key,BST_tree)*** operation to delete an element matching *key* value in a binary search tree.

4. (15%) Given a tree as in Figure 1,
   (a) (5%) Show its inorder traversal.
   (b) (10%) Write a inorder traversal algorithm ***inorder(Tree)*** that returns a list of elements in the inorder traversal order.

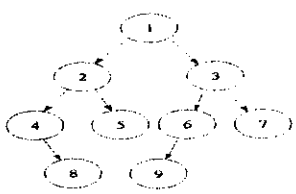


Figure 1

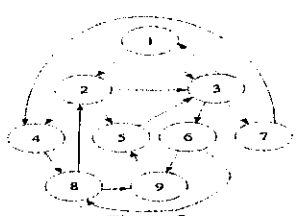


Figure 2

5. (25%) Use the ***breadth-first search*** algorithm to find a shortest path from vertex 9 to vertex 2 in a directed graph as in Figure 2.
   (a) (10%) Show the running steps of the algorithm.
   (b) (15%) Write a pseudo algorithm ***shortestpathlength(V,E,s,d)*** that returns the shortest path length from vertex *s* to vertex *d* where V is a list of vertices with data structure (vertex_id, next) and E is a list of edges with data structure (edge_id, src_vertex_id, dst_vertex_id, next).

6. (10%) In the ***quicksort*** sorting algorithm, a pivot value is chosen from the list of values. It is then compared with the rest of the values in the list to arrange the list of values into two sub-lists. One sub-list contains values greater than the pivot value. The other sub-list contains values smaller than the pivot value. The efficiency of quicksort depends heavily on the way to select pivot values. Given an arbitrary *quicksort* sorting of *n* values, answer the following questions.
   (a) (5%) What is its best case computation time complexity? Explain such situation.
   (b) (5%) What is its worst case computation time complexity? Explain such situation.
   Note: Use big O notation O(f(n)) to specify computation time complexity.

7. (10%) Given the sequence of five values 4, 8, 9, 2, 1, show the running steps of ***heap sort*** of the sequence.

[Problem 1] By Boolean algebra to determine and prove whether or not the following expressions are valid, i.e. whether the left- and right-hand sides represent same function. (10%)

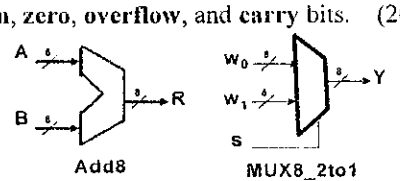
a. $\overline{x2}\cdot\overline{x3}+\overline{x3}\cdot\overline{x4}+x1\cdot x2\cdot x3\cdot x4=(x2+x3)(x3+x4)(\overline{x1}+\overline{x2}+\overline{x3}+\overline{x4})$

b. $(x1+x3)(\overline{x1}+\overline{x2}+\overline{x3})(\overline{x1}+x2)=(x1+x2)(x2+x3)(\overline{x1}+x3)$

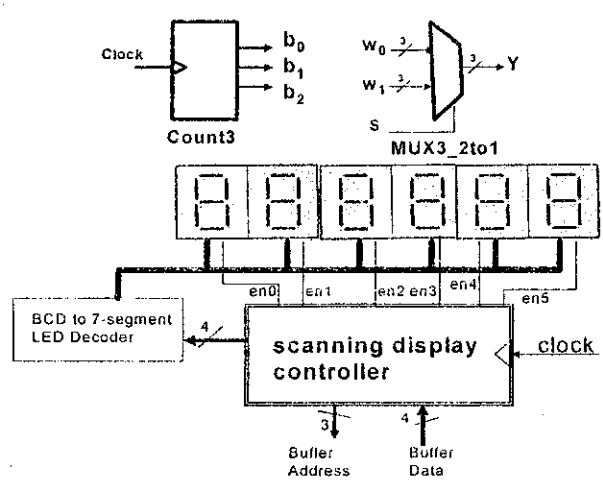
[Problem 2]、 Given the 8-bits fast adder (named Add8), the 2-to-1 8-bits multiplexers (named MUX8_2to1) and the basic gates such as NOT, AND, OR, NAND, and NOR, you are asked to design an ALU in function block diagrams, which must match the following requirements:

(1) Support **add**, **sub**, and **sgt (set on great than)** functions. Their operation selection bits (op_sel) are as follows: add(00), sub(01), sgt(11),

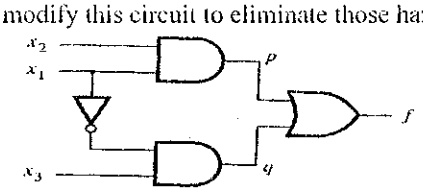
(2) Report the result status in **sign**, **zero**, **overflow**, and **carry** bits. (20%)



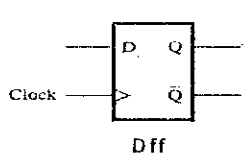
[Problem 3] Given the 3-bits counter (named Count3) , the 2-to-1 3-bits multiplexer (named MUX3_2to1) and the basic gates such as NOT, AND, OR, NAND, and NOR, complete the **scanning display controller** in the following functional block diagram to control six 7-segment display with the scanning display method. (20%)

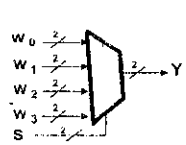


[Problem 4] The output of a combinational circuit may make a transition. Describe what kind hazards maybe happen in the following circuit and modify this circuit to eliminate those hazards. (20%)



[Problem 5] Given the positive-edge-triggered D flip-flop (named Dff), the 4-to-1 2-bits multiplexers (named MUX2_4to1) and the basic gates such as NOT, AND, OR, NAND, and NOR, derive a circuit by the state-assigned table as table 1. (20%)





Present state y_2y_1	Next state Y_2Y_1 (ab = 00 / 01 / 10 / 11)				Output s
	00	01	10	11	
00	00	01	01	10	0
01	00	01	01	10	1
10	01	10	10	11	0
11	01	10	10	11	1

[Problem 6] In VHDL or Verilog HDL, write a 4-bits BCD counter. (10%)

國立中山大學九十三學年度碩士班招生考試試題

科目：計算機結構 【電機工程學系碩士班 丙組】

1. (10%) Calculate how many times the statement x = x +1 are executed after running the following program ?

```
For (I = 1; I <= n; I ++)
    For (J =1; J < = I; J ++)
        For (K =1; K < = J; K ++)
            x = x + 1;
```

2. (10%) IEEE-754 floating-point representation
   (1) (5%) Using 32-bit floating-point format (8-bit exponent, exponent bias = 127, and base = 2) to represent **-1/64**
   (2) (5%) Using 64-bit floating-point format (11-bit exponent, exponent bias = 1023, and base = 2) to represent **-1/32**

3. (20%) A workstation uses 200 MHz processor to execute a given program mix with 50,000 instructions. Assume one cycle is needed for instruction decoding, one cycle is needed for instruction execution, and three cycles are required for one memory reference. On average, every instruction will require two times of memory references.
   (1) (5%) Calculate the total CPU time for executing this program mix.
   (2) (5%) What is the effective CPI (Cycles per Instruction) of this computer?
   (3) (5%) Calculate MIPS (Million Instructions per Second).
   (4) (5%) Calculate the maximum CPU throughput (programs per second).

4. (20%) Consider a cache and a main memory hierarchy, in which cache = **32K words**, main memory = **128M words**, cache block size = **8 words**, and word size = **4 bytes**.
   (1) (5%) Show the physical address format for Direct Mapping (How many bits in Tag, Block, and Word?)
   (2) (5%) Show the physical address format for Fully Associative Mapping (How many bits in Tag, and Word?)
   (3) (5%) Show the physical address format for **4-way** Set Associative Mapping (How many bits in Tag, Set, and Word?)
   (4) (5%) Show the physical address format for Sector Mapping with **16** blocks per sector.
   (How many bits in Sector, Block, and Word?)

5. (20%) Given the following high-level source code. Perform a flow analysis and draw the dependency graph (flow, output, and anti-dependency) among all the statements. Note: use ----> represents flow dependency, ---o--> represents output dependency, and --|--> represents anti-dependency.

```
S1:  A = B + C
S2:  C = D + E
S3:  F = G + E
S4:  C = A + F
S5:  M = G + C
S6:  A = L + C
S7:  A = E + A
```

6. (20%) Identify major differences between the following terminology pairs.
   (1) (5%) SDRAM vs CDRAM
   (2) (5%) RAID-1 vs RAID-2
   (3) (5%) Multi-programming vs Multi-threading
   (4) (5%) Superscalar vs Superpipeline

國立中山大學九十三學年度碩士班招生考試試題

科目：離散數學　電机所（丙組選考）

請注意：必須寫出計算過程或說明得到答案之理由，只寫答案不予計分。

1. Complete the following truth table for the well-formed formula (wff): $(A \rightarrow B) \leftrightarrow (A' \vee B)$. Is this wff a tautology and why? (15%)

A	B	$A \rightarrow B$	A'	$A' \vee B$	$(A \rightarrow B) \leftrightarrow (A' \vee B)$
T	T		F		
T	F		F		
F	T		T		
F	F		T		

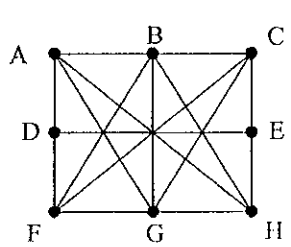
2. A survey of 150 college students reveals that 83 own automobiles, 97 own bikes, 28 own motorcycles, 53 own a car and a bike, 14 own a car and a motorcycle, 7 own a bike and a motorcycle, and 2 own all three.
   a. How many students own a bike and nothing else? (6%)
   b. How many students do not own any of the three? (6%)

3. How many distinct nonnegative integer solutions are there to the equation
   $$x_1 + x_2 + x_3 + x_4 = 10$$
   where the solution $x_1 = 3, x_2 = 1, x_3 = 4, x_4 = 2$ and the solution $x_1 = 4, x_2 = 2, x_3 = 3, x_4 = 1$ are distinct? (12%)

4. Two fair dice are rolled. The sample S contains the 36 combinations of two numbers. For each member (p, q) of S, the random variable $X(p, q) = p + q$.
   a. Write a table showing the values for X and p. Instead of 36 columns each with probability 1/36, do a column for each value of X and show the probability of that value. (8%)
   b. Find the expected value of the sum of the numbers that come up when two fair dice are rolled. (8%)

5. Draw the Hasse diagram for the relation "x divides y" on {1, 2, 3, 5, 6, 10, 15, 30}. (14%)

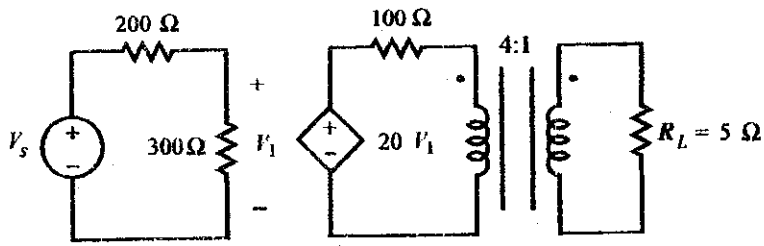
6. Determine if the following graph is planar (by finding a planar representation) or nonplanar. (15%)



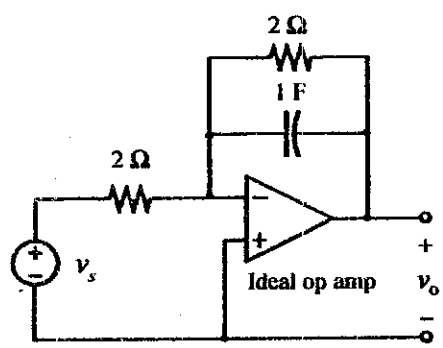
7. Minimize the following finite state machine where S_i is the internal state, {0, 1} is both the input alphabet and output alphabet, v is the next state function and w is the output state function. (16%)

	v		w	
	0	1	0	1
S_1	S_6	S_3	0	0
S_2	S_5	S_4	0	1
S_3	S_6	S_2	1	1
S_4	S_4	S_3	1	0
S_5	S_2	S_4	0	1
S_6	S_4	S_6	0	0

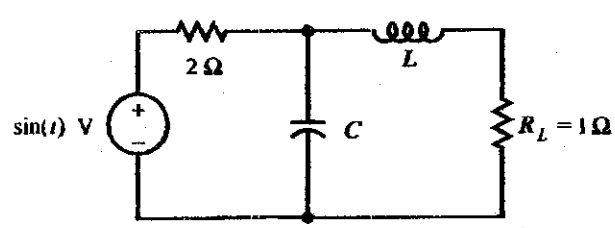
1. In the circuit shown, the sinusoidal input voltage V_s has a magnitude of 1 V rms. Please find the average power delivered to the load R_L (20%).



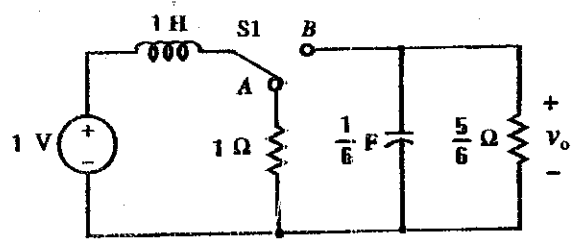
2. In the ideal op-amp circuit shown, where $V_s(s)$ and $V_o(s)$ are the Laplace transforms of $v_s(t)$ and $v_o(t)$, respectively. (1) Find the transfer function $V_o(s)/V_s(s)$ (10%). (2) With zero initial condition, determine the response of the circuit to the unit impulse input, $v_s(t) = \delta(t)$ (10%).



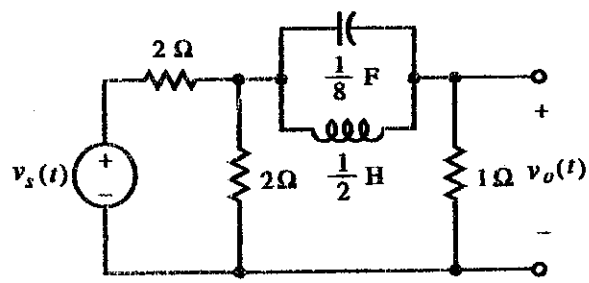
3. In the circuit shown, the input is a sinusoidal voltage source sin(t). Choose L and C so that the power delivered to the load R_L is maximized (20%).



4. In the circuit shown, switch S1 has been in position *A* for a long time. At t=0 it switches to position *B*. Determine v_o for $t \geq 0$ (20%).



5. The input to the circuit shown below is $v_s(t) = 10\sin(\omega t + 0.5)$. For what value of ω will result in zero steady-state output v_o (20%)?



國立中山大學九十三學年度碩士班招生考試試題

科目：電力系統　【電機工程學系碩士班　丁組】

1. Three loads are connected in parallel across a 1400-V rms, 60-Hz single-phase supply as shown in Figure 1.

(20%)

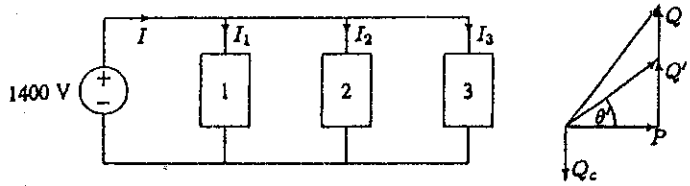


Figure 1

Load 1: Inductive load, 125 kVA at 0.28 power factor.
Load 2: Capacitive load, 10 kW and 40 kvar.
Load 3: Resistive load of 15 kW.

a) Find the total kW, kvar, kVA, and the supply power factor.
b) A capacitor of negligible resistance is connected in parallel with the above loads to improve the power factor to 0.8 lagging. Determine the kvar rating of this capacitor and the capacitance in μ F.
c) Find the total current after the capacitor is installed.

2. Consider two ideal voltage sources connected by a line of impedance Z= R+jX Ω as shown in Figure 2.

(20%)

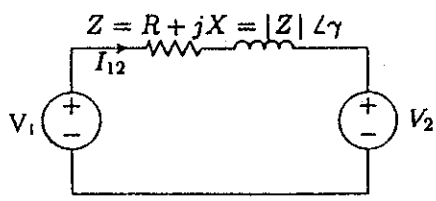


Figure 2

Let the phasor voltage be $V_1 = |V_1|\angle\delta_1$ and $V_2 = |V_2|\angle\delta_2$.
Prove that the real and reactive power at the sending and are

$$P_{12} = \frac{|V_1|^2}{|Z|}\cos\gamma - \frac{|V_1||V_2|}{|Z|}\cos(\gamma + \delta_1 - \delta_2)$$

$$Q_{12} = \frac{|V_1|^2}{|Z|}\sin\gamma - \frac{|V_1||V_2|}{|Z|}\sin(\gamma + \delta_1 - \delta_2)$$

Assuming R = 0 (i.e., $Z = X\angle 90^0$), the above equations become

$$P_{12} = \frac{|V_1||V_2|}{|Z|}\sin(\delta_1 - \delta_2)$$

$$Q_{12} = \frac{|V_1|}{X}[|V_1| - |V_2|\cos(\delta_1 - \delta_2)]$$

3. The generator power angle equation during one system condition is $P_e = 2.10\sin\delta$, assume mechanical power input is 1.0 p.u., show that $\delta = 28.44°$ is a point of stable equilibrium, on the other hand, $\delta = 151.56°$ is a point of unstable equilibrium. (20%)

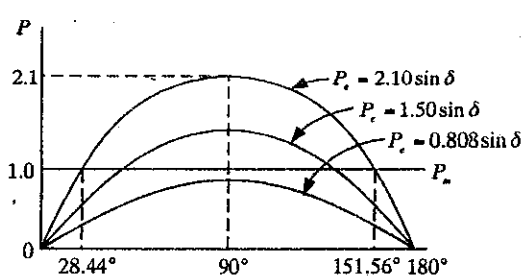


Figure 3.

4. (a) Describe the procedure for power flow solution by the Newton-Raphson method. (10%)
(b) Describe the measures and equipment that can be used to control the real and reactive power flows in a power network. (10%)

5. A load draws current from a practical voltage source, as shown in Figure 5. (20%)

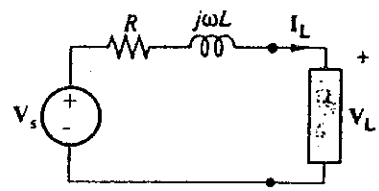


Figure 5

Use the phasor diagrams for the ac circuit, without any numerical calculation, to show that $|V_L|$ could be smaller than, greater than, or equal to $|V_S|$, depending on the phase relationship between I_L and V_L.

Electromagnetics

May 2, 2004

1. Consider a sphere of radius b having uniform charge of volume density ρ in free space. Determine the electrostatic energy of this charge configuration. (20%)

2. The electric field component of an electromagnetic wave in air used by an aircraft to communicate with the air traffic control tower can be represented by

$$\vec{E}(z,t) = \hat{y}0.02\cos(7.5\times10^8 t - \beta z)$$

Find the corresponding wave magnetic field $\vec{H}(z,t)$ and constant β. (20%)

3. Consider a uniform plane wave propagating in air incident normally on a large copper block. Find the percentage time-average power absorbed by the copper block at 1, 10, 100MHz and 1GHz. (hint : conductivity of copper is 5.8×10^7 S/m) (20%)

4. (20%)
   a. Please describe the meaning of the homogeneous and inhomogeneous transmission lines.
   b. Please compare their characteristic impedance and propagation velocity for the following transmission line structures. And explain why

Case1 case2 case3

5. Please derive the approximate expressions for γ and Z_0 for a lossy transmission line at very low frequencies such that $\omega L \ll R$ and $\omega C \ll G$. (20%)

1. Let the random variables X and Y be independent and Gaussian, and assume that each has a mean of zero and a variance of σ^2.

$$f_X(x) = f_Y(x) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp[-\frac{x^2}{2\sigma^2}]$$

If a new random variable Z is defined by

$$Z = a\frac{X}{Y}$$

(a) Find the conditional probability density function of Z given Y. (8%)
(b) What is the probability density function of Z (7%)?

2. Random variables X and Y have respective density functions

$$f_X(x) = \frac{1}{a}[u(x) - u(x-a)]$$

$$f_Y(y) = bu(y)e^{-by}$$

for $a>0$ and $b>0$, and $u(x)$ is denoted as the *unit step* function of x.

(a) Find and sketch the density function of W=X+Y if X and Y are statistically independent. (10%)
(b) What is the moment generating function of W. (10%)

3. (a) Show that the *correlation coefficient* satisfies the expression (8%)

$$|\rho| = \frac{|\mu_{11}|}{\sqrt{\mu_{02}\,\mu_{20}}} \le 1 \quad \text{, where } \mu_{nk} = E[(X-\overline{X})^n (Y-\overline{Y})^k]$$

where $\overline{X} = E[X]$ and $\overline{Y} = E[Y]$. Suppose we wish to predict the value of a random variable Y by observing the values of another random variable X. Assume that the following model is employed to predict Y, that is,

$$Y_p = \alpha X + \beta$$

(***Linear Prediction***) Our task is to adjust the *coefficients* α and β in order to minimize the mean-square error

$$\varepsilon = E[(Y - Y_p)^2]$$

(b) To find the optimum values of α and β (7%), and
(c) the value of *minimum mean-square error*, ε_{min}. (5%)

4. Let X be a random variable and A={X>t}. (a) Find the conditional probability distribution function, $F_{X|A}(x \mid A)$, and (8%)(b) find the conditional density function $f_{X|A}(x \mid A)$. (7%)

5. The probability that a *telephone call* lasts no more than t minute is often described by an *exponential cumulative* distribution function (CDF), i.e.,

$$F_T(t) = \begin{cases} 1 - e^{-at}, & t \geq 0 \\ 0 & ,otherwise \end{cases}$$

For a= 1/3 **(a)** What is the probability density function, f_T(t), of the duration in minutes of a *telephone conversation*. (5%) **(b)** What is the probability that a conversation will last between 2 and 4 minutes. (7%) **(c)** What is E[T] (*mean*) and $E[T^2]$ (8%).

6. Consider a *Binomial* random variable X, with $0 < p < 1$, and N =1,2,…, and the density function, i.e.,

$$f_X(x) = \sum_{k=0}^{N} \binom{N}{k} p^k (1-p)^{N-k} \delta(x-k)$$

(a) Find E[X] (5%) and (b) $E[X^2]$ (5%).

國立中山大學九十三學年度碩士班招生考試試題

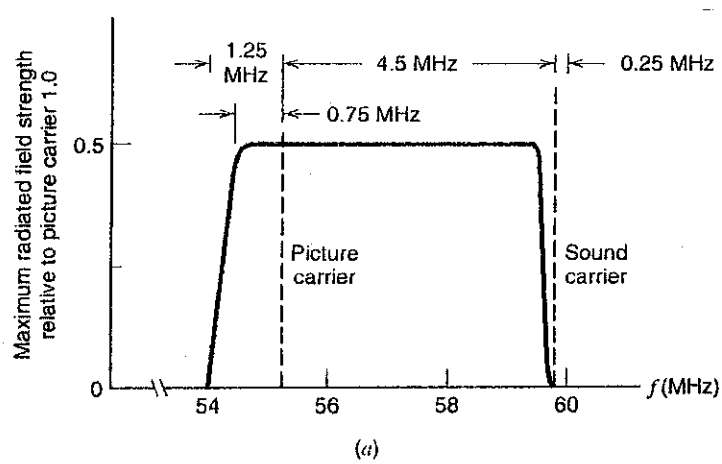
科目：通訊理論 【電機工程學系碩士班 己組】

計分說明：本題計分將採用一種新創的"市場需求調整計分法"，即計分高低(價值)與獲解率(市場需求率之倒數，愈易獲解，市場上需求愈低)成反比。所以考生除了要把握多數人會的題目外，還要著重於自己獨特的能力，即別人不容易會的問題。 在入學徵才錄取率不高的情況下，希望考生能發揮出自己卓越的特點。

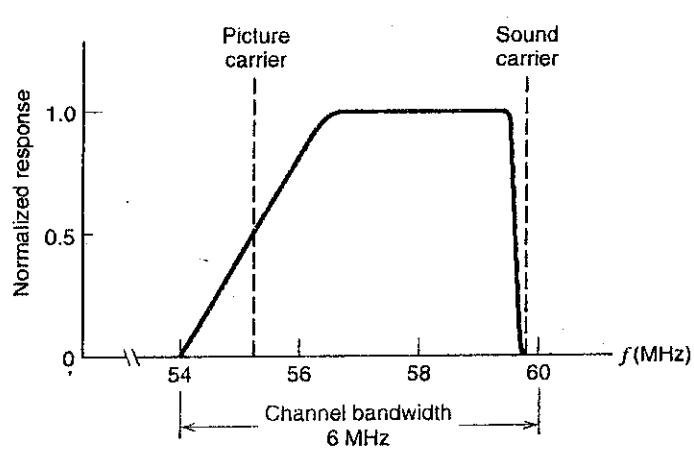
你的得分($S_1', S_2', S_3', \ldots$)公式計算如下：令$R_1, R_2, R_3, \ldots$爲小題各自原始分數給分範圍，$R_1', R_2', R_3', \ldots$爲依市場需求調整後的分數給分範圍，$M_1, M_2, M_3, \ldots$爲小題各自的原始平均得分，$S_1, S_2, S_3, \ldots$ 爲小題各自原始得分：則$S_1' = S_1 \times \frac{R_1'}{R_1}$ 而$R_1', R_2', R_3', \ldots$的計算，在$M_1, M_2, M_3, \ldots$的各小題平均分數算後，依據$R_1' : R_2' : R_3', \ldots = \frac{R_1}{M_1} : \frac{R_2}{M_2} : \frac{R_3}{M_3}, \ldots$得到，且$R_1' + R_2' + R_3', \ldots = 100$ 注意$R_1, R_2, R_3, \ldots$的原始範圍可以任意設定，爲著讓考生易所依循，我仍可以做一次不必要的設定：$R_1 = R_2 = R_3, \ldots = R_6 = 100/6$

1. What is the time average autocorrelation? Please explain why the time average autocorrelation is so defined?

2. An Idealized magnitude spectrum of a transmitted TV signal is shown in Figure (a). The magnitude response of a shaping filter for the TV signal is shown in figure (b).
   (i) Where should this shaping filter be placed? Transmitter or receiver?
   (ii)Please explain by plot how the goal of the shaping filter can be achieved.

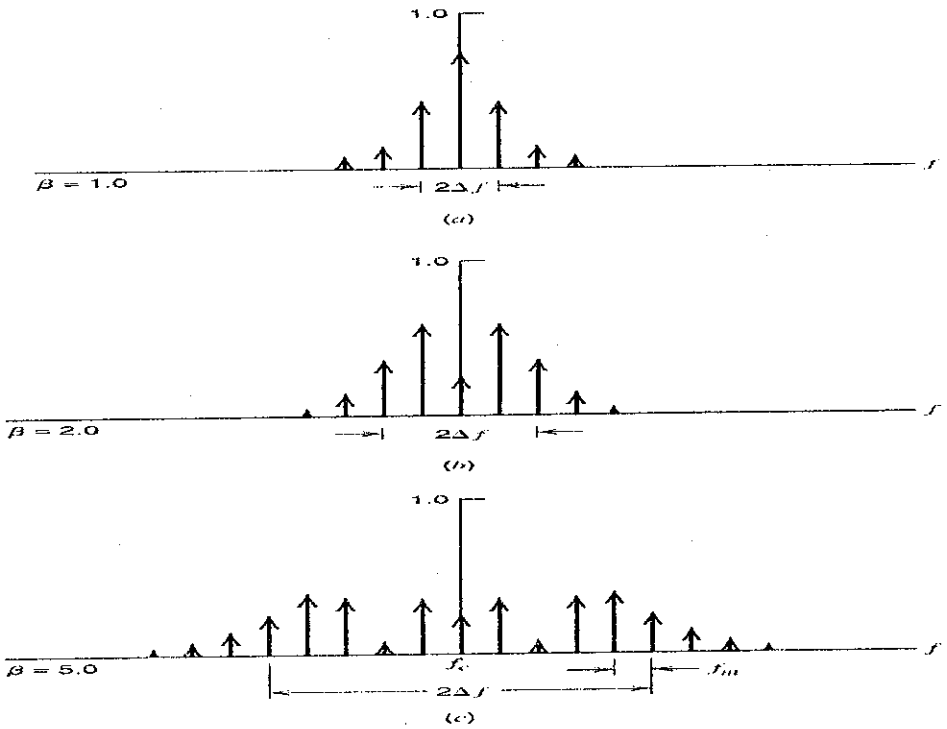


(a)

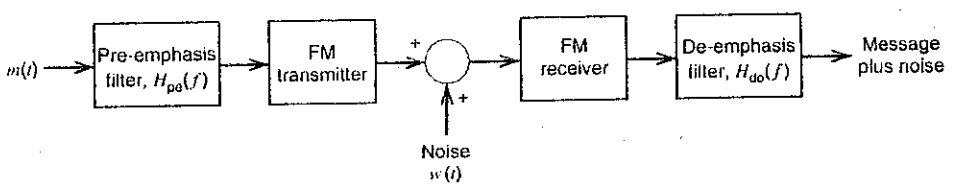


(b)

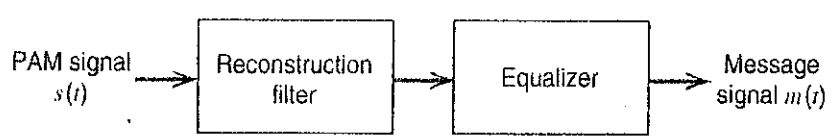
3 Consider the case of a discrete amplitude spectrum of an FM signal, normalized with respect to the carrier amplitude, for the case of sinusoidal modulation of fixed frequency and varying amplitude. Only the spectra for positive frequencies are shown. Please give the definition of Δf and explain the meanings of $2\Delta f$ shown below.



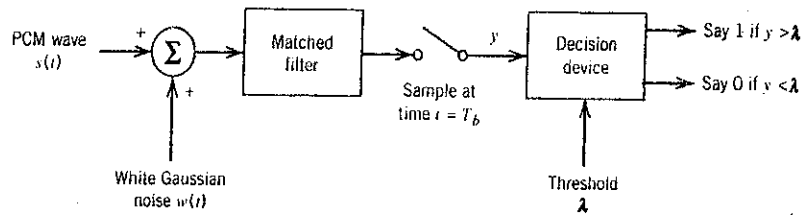
4. Please give the typical plots of the transfer function for the Pre-emphasis filter and De-emphasis filter shown below. Explain how they work.



5. The following system is for recovering message signal $m(t)$ from PAM signal $s(t)$. Please describe the function of the reconstruction filter and equalizer shown below.



6. Receiver for baseband transmission of binary-encoded PCM wave using polar NRZ signaling is shown below. What is the impulse response of this match filter?



國立中山大學九十三學年度碩士班招生考試試題

科目：線性代數　電機所　乙組

Linear Algebra_2004.　Each problem counts for 10 points,　Page1/2

1. Let A be an N by N nonsingular matrix and let b be an element in N-dimensional real number space R^N. Let A_i be the matrix obtained by replacing the ith column of A by b. If x is the unique solution to Ax = b, prove in matrix theory that

$$x_i = \det(A_i)/\det(A) \quad \text{for } i=1,2, \ldots, N$$

2. What is the Wronskian of the N functions $f_1(x)$, $f_2(x)$,.., and $f_N(x)$ defined in $C^{N-1}[a, b]$. Define the terminology and make some examples to illustrate its applications.

3. What is the Cauchy-Schwarz Inequality, state the importance of this inequality in Communication Science and make some real examples to illustrate its applications

4. Let s(0), s(1), s(2), ... ,s(N-1) be the observations from some experiment, we want to find the best linear mean square error (mse) estimate of s(P), s(P+1),.., s(N-1) by the first P samples, s(0), s(1), ..., s(P-1), by some unknown best coefficients a_1, a_2,... , and a_P, that is the linear predicted sample values are the linear combination of the previous P samples :

$$\begin{aligned}
s_mse(P) &= a_1*s(P-1) + a_2*s(P-2) + \ldots + a_P*s(0) \\
s_mse(P+1) &= a_1*s(P) + a_2*s(P-1) + \ldots + a_P*s(1) \\
&\ldots\ldots \\
s_mse(N-1) &= a_1*s(N-2) + a_2*s(N-3) + \ldots + a_P*s(N-P-1)
\end{aligned}$$

solve this problem for the unknown best coefficients a_1, a_2,... , and a_P .

5. Find the best quadratic least square fit to the data set (X, Y) by first deriving the least square error matrix equation and then finding the minimum

X	0	1	2	3
Y	3	2	4	4

6. What are the eigenvalues and the eigenvectors of a matrix? Please explain in a geometric way and find the eigenvalues and their corresponding normalized eigenvectors of the matrix A

$$A = \begin{bmatrix} -2 & +2 & -3 \\ +2 & +1 & -6 \\ -1 & -2 & +0 \end{bmatrix}$$

7. In a certain town 30 percent of the married women get divorced each year and 20 percent of the single women get married each year. There are 8000 married women and 2000 single women and the total population remains constant. Find the number of married women and single women after 5 years. What will be the long-range prospects if these percentages of marriages and divorces continue indefinitely into the future?

8. What is the Parseval's theorem? State the importance of this theorem in Communication Science and make some real examples to illustrate its applications

9. Given

$$A = \begin{bmatrix} +0 & +2 & -1 \\ +2 & +3 & -2 \\ -1 & -2 & +0 \end{bmatrix}$$

Find an orthogonal matrix U that diagonalizes A

10. Let A be a real symmetric N by N matrix. Show that A is positive definite if and only if all its eigenvalues are positive.