國立雲林科技大學
八十九學年度研究所碩士班入學考試試題

系所：電資所
科目：電子電路

計算題共十題

1. Two filters are designed to have the same half-power frequency, $\varpi_H = 1/R_2C_2$. Each is then connected to a source of internal resistance Rs as in Fig. 1.
   (a) (5%) Find and compare the actual filter functions Vo/Vs.
   (b) (5%) What conclusion can we make from this comparison?

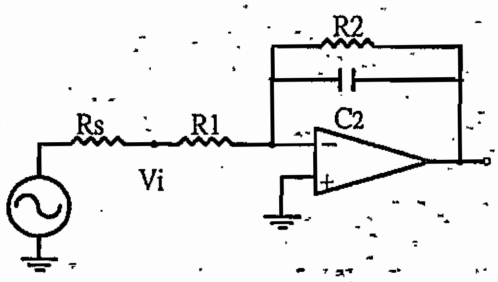

Fig. 1

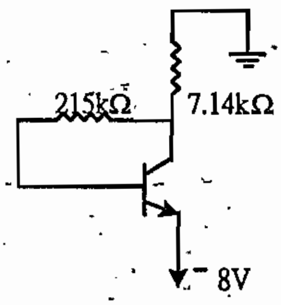

Fig. 2

2. The silicon transistor in Fig. 2 has $\beta = 20$ and is in the forward active mode.
   (a) (5%) Use the large-signal model to find the node voltages at base and collector.
   (b) (5%) Find the quiescent operating point of the transistor, (V_{CE}, I_C).

3. (a) (5%) Find the minimum value of VGG required to turn on the transistor of Fig. 3.
   (b) (5%) What will be the state of the transistor just as it turns on active, or ohmic? Explain your reasoning.

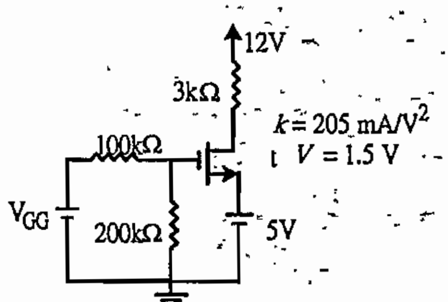

Fig. 3

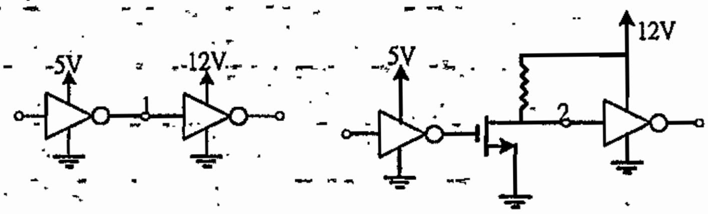

Fig. 4

4. (10%) Fig. 4 shows a 5V CMOS inverter interfaced with a 12V CMOS inverter directly and through an interface circuit. All internal transistors have |Vt|=1V. Compute and compare the noise margins at nodes 1 and 2.

5. (a) (5%) Draw an NMOS circuit that realizes the function $\overline{Z} = (A \cdot B + C \cdot D) \cdot E$.
   (b) (5%) Draw an CMOS circuit that realizes the function $Z = (A \oplus B + C) \cdot D$.

6. (10%) Design an MOS current mirror as shown in Fig. 5 having outputs of 1mA, 2.5mA, and 5mA. The diode connected transistor has parameters V_t=0.5V and k=2.5mA/V^2. The power supply is 12V.

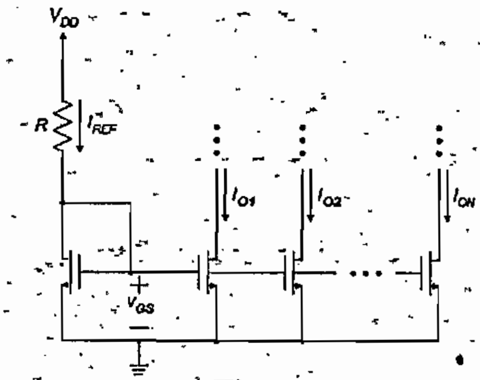

Fig. 5

7. (10%) The Bode plots of Fig. 6 describe the open-loop gain of an op amp. Find gain and phase margins of a noninverting feedback amplifier using this op amp when β=0.00179.

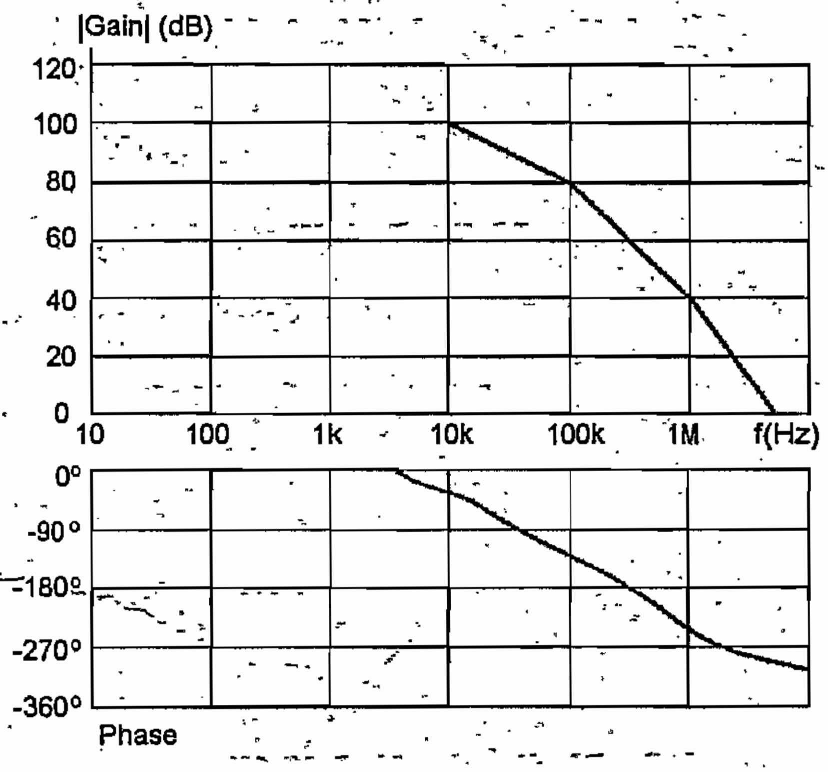

Fig. 6

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8. (10%) Analyze the circuit of Fig. 7 to show that the source resistance R_S increases the output resistance over its original value of r_o, i.e. without the source resistance R_S.

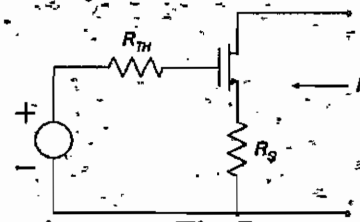

Fig. 7

9. (10%)Find gain function $A(s)$ that have Bode plots like those of Fig. 8

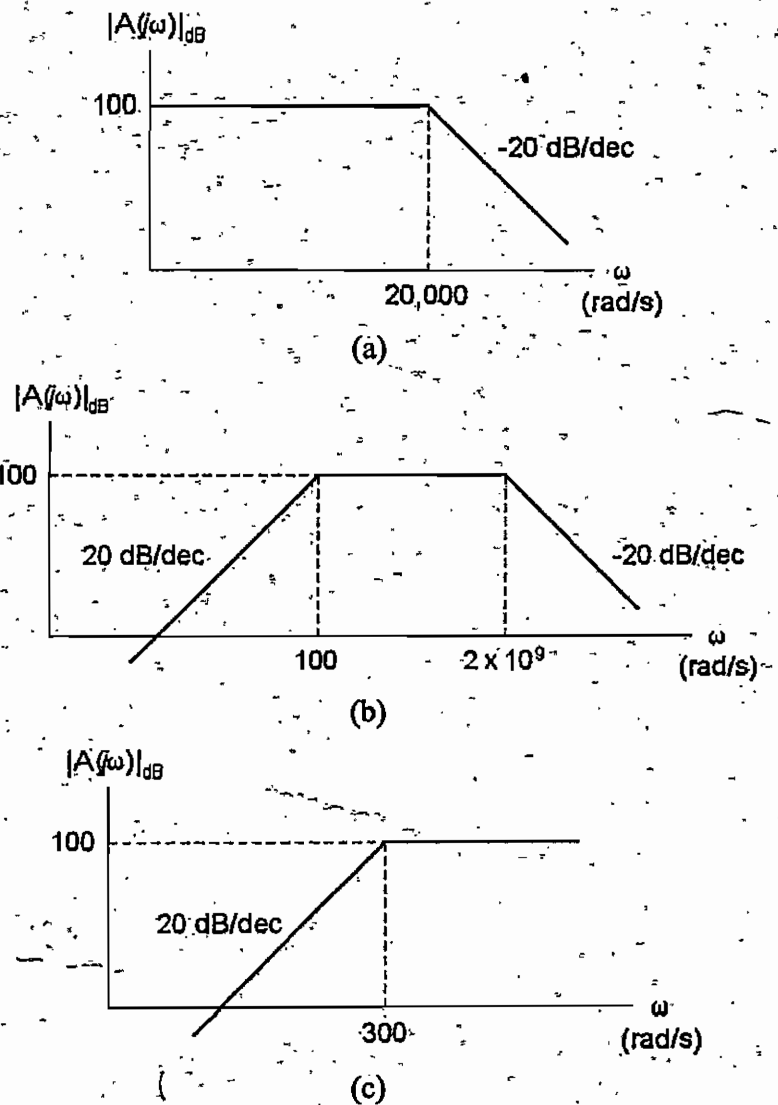

Fig. 8

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10. (a) (5%) How fast does the gain of a second-order lowpass filter roll off in the stopband?
    (b) (5%) What is the maximum phase shift introduced by a second-order lowpass filter at high frequencies?

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系所：電資所
科目：計算機概論 (甲)

1. (15pts) A combination switching network has 4 inputs (A, B, C, D) and one output (F). $F = 0$ iff 3 or 4 of the inputs are 0.
   a. Write the maxterm expansion of F, i.e., express F as a product of maxterms. (7pts)
   b. Using AND and OR gates, find a *minimum* three-level network to realize F. (8pts) (**Note:** *You should try to minimize the number of used gates and the total number of gate inputs at the same time.*)

2. (20pts) A Mealy sequential network has 1 input (X), 1 output (Z) and 2 flip-flops (Q_1 and Q_2). A timing chart for the network is shown in Figure 1.
   a. Please construct a *state table* for the network. (8pts)
   b. Implement the network if J-K flip-flops are used for Q_1 and Q_2. (7pts)
   c. Describe the difference between Mealy and Moore sequential networks. (5pts)

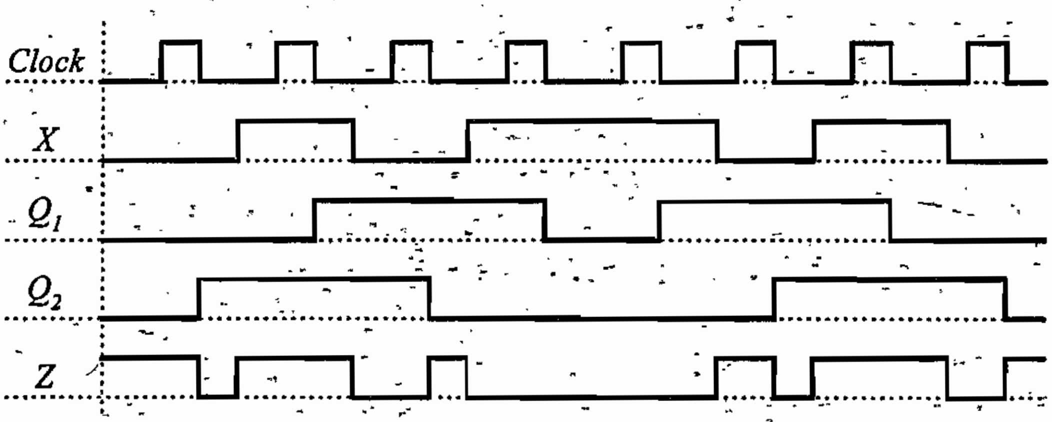

Figure 1

3. (15pts) A signed-digit (*SD*) system is a fixed-radix number system that each digit is either positive or negative and therefore there is no need for a separate sign digit. For example, if the radix r =10 and each digit can be one of the elements in the digit set $\{\overline{(r-1)}, \overline{(r-2)}, \ldots, \bar{1}, 0, 1, \ldots, (r-1)\}$, then we have $(0\bar{1}) = (1\bar{9}) = 1$; $(0\bar{2}) = (\bar{1}8) = -2$.
   a. Given a decimal number with the value $(-14)_{10}$, please find all the possible six-digit *SD* representations with the radix $r = 2$. (5pts)
   b. If each digit can be one of the element in the digit set $\{\bar{a}, \overline{(a-1)}, \ldots, \bar{1}, 0, 1, \ldots, a\}$, please find the lower bound on the value a such that each number have at least one representation in this *SD* number system. (4pts)
   c. In your opinion, what is the advantage by using the *SD* number system. (3pts)
   d. Is it possible to have more than one representation of 0 in an *SD* system? (3pts) (**Note:** You need to justify your answer)

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4. (10pts) Consider the following register transfer statements

S: $PR \leftarrow 0, S \leftarrow 0, D \leftarrow 0, F \leftarrow 1$

F: $F \leftarrow 0$, if $(AR = 0)$ then $(D \leftarrow 1)$ else $(R \leftarrow 1)$,

R: $PR \leftarrow PR + BR, AR \leftarrow AR - 1, R \leftarrow 0, F \leftarrow 1$

The variable (i.e. S, F and R) at the beginning of each statement means the predicate condition of executing the statement. For example, the first statement can be interpreted as

If $S = 1$, Then PR, S and D are set to 0 and F is set to 1.

a. What are these statements for? (4pts)

b. Draw a block diagram of the hardware implementation (6pts)

5. (20pts) recursive merge sort design

a. Please describe a merging procedure, which merges two sorted lists L_1 and L_2 of equal length n and produces a single sorted list L. For example, given L_1={1,2,7,7,9} and L_2={2,3,7,8,10}, the sorted list L={1,2,2,3,7,7,7,8,9,10}. For clarity, pseudo code is preferable. (5pts)

b. Please calculate the computing complexity (in terms of n) of your merging procedure described in **a.** (5pts)

c. Using the principle of divide-and-conquer, please derive a recursive merge sorting algorithm. (5pts)

d. Please design a hardware function unit capable of performing your recursive merge sort algorithm. (Block diagram plus necessary explanation for circuit operation). (5pts)

6. (20pts) Connected components and minimal spanning tree of an undirected graph

a. For an undirected graph, please describe an algorithm to find all the connected components in the graph (5pts)

b. Please evaluate the Big-O computing complexity of your algorithm (5pts)

c. What is the minimal spanning tree of a graph with weighted edges (5pts)

d. Revise the algorithm derived in **a.** to find the minimal spanning tree of a graph (5pts)

(**Note:** *please describe your algorithms in pseudo codes plus sufficient explanation*)

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1. Compute the Big-oh Notation of the following program segment: (10 pints)

```
for i = 1 to n do
    for j = 1 to i do
        for k = 1 to j do
            print i + j
```

2. Define recursively the set of odd parity strings. (10 points)

3. For the expression as shown below, construct the expression tree and find the equivalent postfix expression: (10 points)

   $((((a * t + b) * t + d) * t + e) * t + f$

4. Suppose you must sort a list of six names, and you have already designed an algorithm that sorts a list of four names. Design an algorithm to sort a list of six names by taking advantage of the previously designed algorithm. (10 points)

5. Suppose each non-shareable resource in a computer system is classified as a level 1, level 2, or level 3 resource. Moreover, suppose each process in the system is required to request the resources it needs according to this classification: That is, it must request the required level 1 resources at once before requesting any level 2 resources. Once it receives the level 1 resources, it can request all the required level 2 resources, and so on. Can deadlock occur in such a system? Why or why not? (10 points)

6. What is a preorder traversal of the nodes of a tree? Write an algorithm to traverse a tree in preorder. Give an example to illustrate your algorithm. (10 points)

7. Write an algorithm to do a breadth first search to find a node in a graph. What are its strength and weakness? Give an example to illustrate the algorithm. (10 points)

8. What is a binary search tree? Write an algorithm to insert a node in a binary search tree. Give an example to illustrate your algorithm. (10 points)

9. Write an algorithm to find the shortest path in a graph from one node to anther. Give an example to illustrate your algorithm. (10 points)

10. What is closed hashing with linear probing? Write an algorithm to insert a record with such hashing. Give an example to illustrate your algorithm. (10 points)

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系所：電資所
科目：微電子學

4. (a) Explain the physical meaning of the carrier mobilities in a semiconductor. (7%)
   (b) Describe the relationship between the resistivity and the carrier mobilities in a semiconductor. (8%)

5. Define a multiplexer and draw the logic block diagram of a 4-to-1-line digital multiplexer. (15%)

6. Draw the block diagram of a 5-bit synchronous counter with series carry using T-type flip-flops and explain its operation. (20%)

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1. (15%) Find the probability density function of $T = \sqrt{X^2 + Y^2}$ where X and Y are two iid random variables with a Gaussian density function with mean equal to zero and variance equal to σ^2.

2. (20%) A random process $Z(t)$ takes values 0,1. A transition from 0 to 1 or from 1 to 0 occurs randomly, and the probability of having n transitions in a time interval of duration $\tau > 0$ is given by

$$p_N(n) = \frac{1}{1+\alpha\tau}\left(\frac{\alpha\tau}{1+\alpha\tau}\right)^n, \quad n=0,1,2,\ldots$$

where $\alpha > 0$ is a constant. We further assume that at $t = 0$, $Z(0)$ is equally likely to be 0 or 1.

(a) Find the autocorrelation function of $Z(t)$.

(b) Determine the power spectral density of $Z(t)$.

3. (15%) A stationary random process has an autocorrelation function given by

$$R_X(\tau) = \frac{A^2}{2} e^{-|\tau|} \cos(2\pi f_0 \tau)$$

and it is known that the random process never exceeds 6 in magnitude. Assuming $A = 6$, how many quantization levels are required to guarantee a SQNR (Signal-to-Quantization-Noise-Ratio) of at least 70dB?

4. (15%) Consider a system with input signal $x(t)$ and output signal

$$y(t) = x(t) + x(t-2) + a\ sgn[x(t)] + b\ y(t-1) + c\ y(t+1),$$

where $sgn[v] = 1, 0, -1$, respectively for $v > 0$, $v = 0$, and $v < 0$.

(a) Is the system linear?

(b) Is the system time-invariant?

(c) Is the system causal?

(d) Find $Y(f)$, the Fourier transform of $y(t)$, in terms of $X(f)$.

(e) Find the impulse response $h(t)$ of the system for $a = 0$.

5. (15%) Consider a linear block code C with parity-check matrix

$$H = \begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 1 \end{bmatrix}.$$

(a) Find the code rate $\frac{k}{n}$ and generator matrix G.

(b) List all the code vectors and find the minimum distance d_{min}=?

(c) Is this code a cyclic code? Explain.

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科目：通信系統

6. (20%) Suppose we would like to design a digital modulation system with four signals $s_m(t)$, $m = 1, \ldots, 4$. Assume these signals are equally likely to be generated by the modulator. The Fourier transforms of these signals are

$$S_1(f) = sinc^2(f), \quad S_2(f) = \frac{1}{j\pi f} * sinc^2(f)),$$

$$S_3(f) = -S_1(f), \quad S_4(f) = -S_2(f),$$

where $*$ denotes convolution, $sinc(x) = sin(\pi x)/(\pi x)$, and $sgn(x) = 1, 0, -1$, respectively, for $x > 0$, $x = 0$, and $x < 0$.

(a) Find $s_1(t)$ and $s_2(t)$.

(b) Find the orthonormal basis for these four signals.

(c) Plot the signal constellation and the decision regions.

(d) Find the bit error probability for AWGN (additive white Gaussian noise) channel with noise power spectral density $\frac{N_0}{2}$.

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1. To carry out a put operation into main memory, what actions are performed by a processor and main memory? You should mention actions, registers, and system buses used. (18%)

2. Please describe the fetch phase of a processor using four steps. (12%)

3. How does a SIC/XE machine recognize an instruction as a SIC instruction? (10%)

4. Can Java run on any machine? What is needed to run Java on a computer? (10%)

5. Suppose that a computer primarily uses direct addressing, but has several different instruction formats. What problems does this create for the relocation-bit approach to program relocation? How might these problems be solved? (15%)

6. None of the disk-scheduling disciplines, except FCFS, are truly fair(starvation may occur). (14%)
(a)Explain why this assertion is true. (7%)
(b)Describe a way to modify algorithms such as SCAN to ensure fairness. (7%)

7. In each of the following statements, determine whether it is True or False and give your reason. (21%)
(a)Optimal page replacement algorithm considers reference string in the past.
(b)Referenced bit and Modified bit are not enough to implement the LRU.
(c)In a multiprogramming system, it would rather give priority on the CPU-bound program than on the I/O-bound program when both are in memory.
(d)Segments have logically independent address spaces.
(e)A segment can be shared among several processes and also be paged.
(f)Ready queue must be designed to a first-in first out queue.
(g)That a cycle exists in the resource-allocation graph implies that a deadlock has occurred.

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系所：電資所
科目：半導體元件

1. A silicon pn junction diode at $T = 300$ °K has a cross-sectional area of 10^{-2} cm^2. The length of the p-region is 0.2 cm and the length of the n-region is 0.1 cm. The doping concentrations are $N_d = 10^{15}$ cm^{-3} and $N_a = 10^{16}$ cm^{-3}. Determine (a) approximately the series resistance of the diode and (b) the current through the diode that will produce a 0.1 volt drop across this series resistance. (15%)

2. In a p-type silicon semiconductor, excess carriers are being generated at the end of the semiconductor bar at X=0. The doping concentration is $N_a = 5\times10^{16}$ cm^{-3} and $N_d = 0$. The steady state excess carrier concentration at X = 0 is 10^{15} cm^{-3} (neglect surface effects). The applied electric field is zero. Assume that $\tau_{n0} = \tau_{p0} = 8\times10^{-7}$ sec. (a) Calculate δn, and the electron and hole diffusion current densities at X = 0. (b) Repeat part (a) for $X = L_n$. (20%)

3. (a) The reverse saturation currents of a Schottky diode and a pn junction at $T = 300$ °K are 5×10^{-8} A and 10^{-12} A, respectively. The diodes are connected in parallel and are driven by a constant current of 0.5 mA. Please determine the current in each diode and the voltage across each diode. (b) Repeat part (a) if the diodes are connected in series. (15%)

4. A silicon npn bipolar transistor at $T = 300$ °K has an area of 10^{-3} cm^2, neutral base width x_B of 1 μm, and doping concentrations of $N_E = 5\times10^{18}$ cm^{-3}, $N_B = 10^{17}$ cm^{-3}, $N_C = 10^{16}$ cm^{-3}. $D_E = D_B = 25$ cm^2/sec, $x_B = x_E$, $\tau_{E0} = \tau_{B0} = 10^{-7}$ sec, and $\tau_{C0} = 10^{-6}$ sec. Assuming the transistor is biased in the active region, calculate (a) the collector current for $V_{BE} = 0.5$V, (b) the current gain (I_C/I_B) when the recombination factor is unity, and (c) the current gain when the recombination factor is 0.99. (15%)

5. The experimental characteristics of an ideal n-channel MOSFET biased in the saturation region are shown in figure 5. (a) Determine V_T and μ_n if W/L = 10 and $t_{ox} = 400$ Å. (b) If the required rated current $I_D(sat) = 5$ mA when $V_{GS} = 5$ volts, determine the required W/L ratio. (15%)

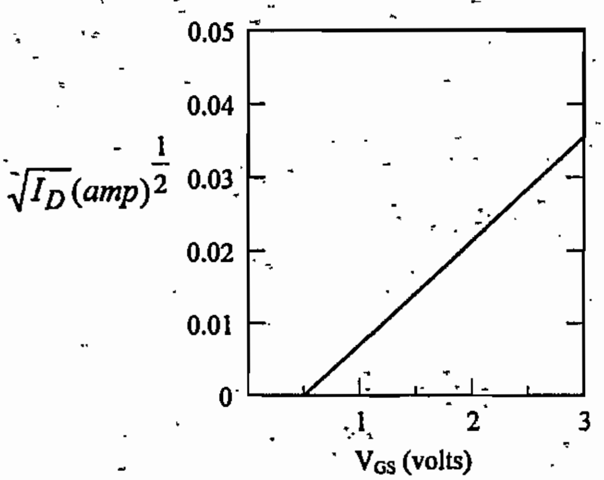

Figure 5: MOSFET characteristics for Problem 5.

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B.4 Silicon, gallium arsenide, and germanium properties ($T = 300°K$)

Property	Si	GaAs	Ge
Atoms (cm^{-3})	5.0×10^{22}	4.42×10^{22}	4.42×10^{22}
Atomic weight	28.09	144.63	72.60
Crystal structure	Diamond	Zincblende	Diamond
Density (g/cm^{-3})	2.33	5.32	5.33
Lattice constant (Å)	5.43	5.65	5.65
Melting point (°C)	1415	1238	937
Dielectric constant	11.7	13.1	16.0
Bandgap energy (eV)	1.12	1.42	0.66
Electron affinity, χ, (volts)	4.01	4.07	4.13
Effective density of states in conduction band, N_c, (cm^{-3})	2.8×10^{19}	4.7×10^{17}	1.04×10^{19}
Effective density of states in valence band, N_v, (cm^{-3})	1.04×10^{19}	7.0×10^{18}	6.0×10^{18}
Intrinsic carrier concentration (cm^{-3})	1.5×10^{10}	1.8×10^{6}	2.4×10^{13}
Mobility (cm^2/V-s)			
Electron, μ_n	1350	8500	3900
Hole, μ_p	480	400	1900
Effective mass, $\left(\frac{m^*}{m_0}\right)$			
Electrons	$m_l^* = 0.98$ $m_t^* = 0.19$	0.067	1.64 0.082
Holes	$m_{lh}^* = 0.16$ $m_{hh}^* = 0.49$	0.082 0.45	0.044 0.28
Effective mass (density of states)			
Electrons, $\left(\frac{m_n^*}{m_0}\right)$	1.08	0.067	0.55
Holes, $\left(\frac{m_p^*}{m_0}\right)$	0.56	0.48	0.37

B.3 Physical constants

Avogadro's number	$N_A = 6.02 \times 10^{23}$ atoms per gram molecular weight
Boltzmann's constant	$k = 1.38 \times 10^{-23}$ J/K $= 8.62 \times 10^{-5}$ eV/K
Electronic charge (magnitude)	$e = 1.60 \times 10^{-19}$ C
Free electron rest mass	$m_0 = 9.11 \times 10^{-31}$ kg
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H/m
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-14}$ F/cm $= 8.85 \times 10^{-12}$ F/m
Planck's constant	$h = 6.625 \times 10^{-34}$ J-s $= 4.135 \times 10^{-15}$ eV-s $\frac{h}{2\pi} = \hbar = 1.054 \times 10^{-34}$ J-s
Proton rest mass	$M = 1.67 \times 10^{-27}$ kg
Speed of light in vacuum	$c = 2.998 \times 10^{10}$ cm/s
Thermal voltage ($T = 300°K$)	$V_t = \frac{kT}{e} = 0.0259$ volt $kT = 0.0259$ eV

B.6 Properties of SiO_2 and Si_3N_4 ($T = 300°K$)

Property	SiO_2	Si_3N_4
Crystal structure	[Amorphous for most integrated circuit applications]	
Atomic or molecular density (cm^{-3})	2.2×10^{22}	1.48×10^{22}
Density ($g\text{-}cm^{-3}$)	2.2	3.4
Energy gap	≈9 eV	4.7 eV
Dielectric constant	3.9	7.5
Melting point (°C)	≈1700	≈1900

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系所：電資所
科目：光電概論

本試卷共有七大題，總分 100 分

1. Suppose that we have a pair of crossed polarizers with transmission axes vertical and horizontal. The beam emerging from the first polarizer has flux density, I_1, and of course no light passes through the analyzer (i.e., $I_2 = 0$). Now insert a perfect linear polarizer with its transmission axis 45° to the vertical between the two elements. Compute the I_2. (10 分)

2. A ray of light makes an angle of incidence of 45° at the center of the top surface of a transparent cube of refractive index 1.414. Trace the ray through the cube as shown in figure 1. (Carefully draw lines and angles to indicate the trajectory of ray.) (10 分)

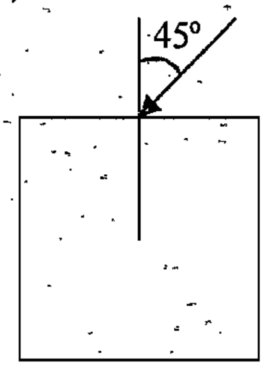

Figure 1

3. A thin film of MgF_2 (n = 1.38) is deposited on glass so that it is antireflecting at a wavelength of 580 nm under normal incidence. What wavelength is minimally reflected when the light is incident at 45°? (20 分)

4. (a) The atomic mass number of copper is 63.54 and the density of copper is 8.9×10^3 kgm^{-3}; Prove that its Fermi level is about 7.0 eV. (10 分)

(b) Calculate the maximum wavelength of light which will give rise to the photoeffects in intrinsic GaAs (Eg = 1.43 eV) and InSb (Eg = 0.225 eV), where Eg is the energy gap. (5 分)

5. (a) An optical power of 1 mW is launched into an optical fiber of length 100 m. If the power emerging from the other end is 0.3 mW, calculate the fiber attenuation in dB/km (ignore reflection losses). (5 分)

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(b) A step index fiber has a numerical aperture of 0.16, a core refractive index of 1.450 and a core diameter of 90 μm. Calculate (i) the acceptance angle of the fiber, (5 分) (ii) the refractive index of the cladding, (5 分) (iii) If the fiber is immersed in water (refractive index 1.33), calculate the acceptance angle of the fiber? (5 分)

6. If the halfwidth of the He-Ne 632.8 nm transition is 2000 MHz, what must be the length of the laser cavity to ensure that only one longitudinal mode oscillates? (10 分)

7. 解釋名詞：(15 分)
   (a) Photoluminescence (3 分)
   (b) Birefrigence (3 分)
   (c) Interband transition (3 分)
   (d) Exciton (3 分)
   (e) Phonon (3 分)

物 理 常 數

（作爲考生解題參考之用）

Rest mass of electron	m	$= 9.110 \times 10^{-31}$ kg
Charge of electron	e	$= 1.602 \times 10^{-19}$ C
Avogadro's constant	N_A	$= 6.022 \times 10^{23}$ mol^{-1}
Planck's constant	$h/2\pi$	$= 6.626 \times 10^{-34}$ Js
Speed of light(in vacuum)	c	$= 2.998 \times 10^{8}$ ms^{-1}