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) $dE_f/dx>0$, (f) $dE_f/dx=0$,(g) none of above (10%)

2) In the energy band diagrams, for a Ge (10^{14} cm^{-3}) doped silicon, the Fermi level, E_F is located at (a) closer to E_C above E_{Fi} , (b) closer to E_V below E_{Fi} , (c) $E_F = E_{Fi}$ (d) closer to the middle gap, E_i above E_{Fi} (e) closer to the middle gap , E_i below E_{Fi} , (f) $E_F = E_i$,(g) none of above. Where E_{Fi} is the intrinsic Fermi level. Choose and explain the corrective answer.(10%)

3) With increasing temperature and neglecting the change of energy band gap, the Fermi level of a doped semiconductor will (a) unchanged (b)move toward conduction band edge E_C (c) move toward valence band edge E_V (d) move to the middle gap (e) move toward band edge and then move toward middle edge (f) none of above Choose and explain the corrective answer.(10%)

4) How to obtain a diode with a ideal I-V characteristics ? (10%)

5) For an intrinsic semiconductor, where is the position of Fermi level in the band gap (a) toward to E_C above E_i , (b) toward to E_V below E_i , (c) $E_F = E_i$ (d) none of above Where E_F is the intrinsic Fermi level and E_i is the position at middle gap. Choose and explain the corrective answer.(10 %)

6) 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. Choose and explain the corrective answer.(10%)

7) (a)How to design a high current gain transistor. (10%).

(b)To calculate the common emitter current gain of a silicon npn bipolar transistor at T=300 K given a set of parameters (10%)

D_E=10 cm^2/sec	J_{RO} =5×10^{-8} A/cm	$n_i = 1.5\times10^{10}$ cm^{-3}	τ_{Eo}=1×10^{-7} sec
D_B=25 cm^2/sec	N_E =1×10^{18} cm^{-3}	X_B=0.70 μm	τ_{Bo}=5×10^{-7} sec
V_{BE} =0.65 volt	N_B =1×10^{16} cm^{-3}	X_E=0.50 μm	

8) Describe the ideal Capacitance-Voltage characteristics of MOSFET and compare with the practical MOSFET. (10%)

9) Brief description on the future trend of semiconductor industry in Taiwan. (10%)

- **There are 5 problems, each counts 20 points.**

Problem #1

Please answer following questions, in English, clearly.

(a) Why use the *Laplace transformation* in control systems study?

(b) Why use the *feedback* in control systems design, e.g. the benefits or disadvantages?

(c) What are the concepts of *controllability* and *observability*?

(d) What is the *Lyapunov stability theorem* saying?

Problem #2

Consider the dynamic system

$$\dot{x}_1 = -x_2 + u$$
$$\dot{x}_2 = ku \quad ; \quad k \in \mathbb{R}$$
$$y = x_1 + x_2 .$$

Let $u = r - y$, where r is the reference signal.

(a) Determine the range of k so that the closed-loop system is asymptotically stable.

(b) Draw the entire root locus (for all $k \in \mathbb{R}$) of the closed-loop characteristic equation as clearly as possible, i.e. indicating the coordinates of all intersections and the corresponding values of k, etc.

Problem #3

For any matrix $A \in \mathbf{R}^{m\times n}$, the induced norm of it is defined as

$$\|A\| := \sup_{\|x\|=1} \|Ax\| .$$

Show that

(a) $\|Ax\| \le \|A\| \cdot \|x\|$, for any $x \in \mathbf{R}^n$.

(b) $\|A + B\| \le \|A\| + \|B\|$, for any A, B in $\mathbf{R}^{m\times n}$.

(c) $\|AB\| \le \|A\| \cdot \|B\|$, for any compatible A and B.

Problem #4

Consider the dynamic system

$$\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \end{pmatrix} = \begin{pmatrix} -1 & 5 \\ -6 & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u$$
$$y = \begin{pmatrix} 1 & 0 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix} .$$

Suppose that the control is obtained from the state feedback $u = -k_1 x_1 - k_2 x_2 + r$.

(a) Find the values of k_1 and k_2 such that the closed-loop system has

$$\xi = 0.707 \quad \text{and} \quad \omega_n = 10 \ rad/\sec .$$

(b) Find the locus in k_1 vs. k_2 plane on which the steady-state error e_{ss} due to the unit step input is zero.

Problem #5

Consider the input-output description of a linear time-invariant dynamic system

$$y(t) = \int_0^\infty u(t-\tau) g(\tau) d\tau \quad \text{for} \quad t \ge 0$$

where $g(\cdot)$ is the impulse response of the system.

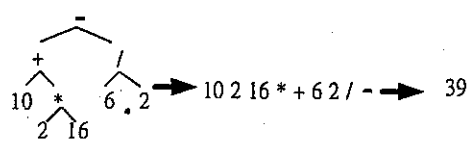
Show that the system is BIBO stable if and only if $\int_0^\infty |g(\tau)| d\tau < \infty$.

國立中山大學九十一學年度博士班招生考試試題

科目：計算機概論【電機系丙組】

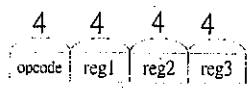
1. (30%)
   (a) (5%) If a graph has n vertices (distinct) and e edges ($n(n-1)/2 \geq e$), how many distinct graphs can be formed to satisfy above requirement?
   (b) (5%) If $e = n-1$, how many distinct tree graphs can be formed?
   (c) (10%) If $e < n-1$, how many distinct k-component disjoint clique graphs can be formed?
   Note: A k-component disjoint clique graph is a graph with k disconnected components each of which is a complete graph.
   (d) (10%) If n vertices is partitioned into two subsets that each has n_1 and n_2 vertices, respectively, how many bi-partite graphs can be formed with these two vertex subsets?
   Note: A bi-partite graph is a graph that has two disjoint vertex subsets where there are only edges connecting vertices between these two vertex subsets.

2. (25%)
   (a) (10%) Write a subprogram to traverse a parser tree and transform into its postfix expression
   (b) (15%) Write an evaluation subprogram to evaluate a given postfix expression
   Note: A sample parser tree, its postfix expression, and its evaluation result are given as followed:



3. (15%) In a 32-bit machine, each byte has a distinct address. There is a 32KB 4-way set associative cache where each cache block contains 64 bytes. When the processor performs the cache access given address ADDR<31:0>, draw a **circuit diagram** of the cache design and **labeled operations and sample data** on it to show **operation sequences** of **a cache hit access** and **a cache miss access** on this cache.

4. (30%) Design the datapath of a simple processor that
   - it has 16 16-bit registers, a program counter, an instruction register, an ALU, a program memory with 16-bit address, and a data memory with 16-bit address
   - it can perform the instructions :
     - add reg1, reg2, reg3 # add reg2 and reg3 into reg1
     - subtract reg2, reg2, reg3 # subtract reg3 from reg2 into reg1
     - logical_AND reg1, reg2, reg3 # bitwise AND reg2 and reg3 into reg1
     - load reg1, reg2 # load reg1 from data in data memory at address in reg2
     - store reg1, reg2 # store reg 1 into data in data memory at address in reg2
   - 4-bit opcodes for add, subtract, logical_AND, load, and store instructions are 0000, 0001, 0100, 0010, and 0011, respectively
   - the instruction format is



   Given a 32-bit ALU that can perform addition/subtraction, and AND operations, **design a datapath** that can perform above instructions

國立中山大學九十一學年度博士班招生考試試題

科目：電力工程【電機系丁組】

(1) 說明電費計算應如何考慮電力負載之需量(demand)和功率因數。(25%)

(2) 列舉電力系統中產生諧波的來源，並說明抑制的方法。(25%)

(3) 說明一同步發電機與運轉中之電力系統並聯工作的步驟和條件，以及並聯後如何調整所供應之功率(實功率及虛功率) (25%)。

(4) 設計一電腦「內建」之不斷電系統，繪系統方塊圖，並說明各方塊之功能。(25%)

國立中山大學九十一學年度博士班招生考試試題

科目：電磁波及光電工程導論【電機系戊組】

本科共分「電磁波」及「光電工程導論」兩大部份，請任選一部份作答。

電 磁 波

1. Show that, if the wavelength of an electromagnetic wave in an unbounded medium characterized by μ and ε is greater than $2a$, then this wave cannot propagate in a rectangular waveguide of dimensions $a \times b$ with the dielectric inside the waveguide also characterized by μ and ε. (25%)

2. Derive the complete time-harmonic fields of the TE wave in a parallel-plate waveguide starting from the Helmholtz equation. (25%)

3. A uniform plane wave impinges obliquely on a plane interface between two dielectric materials of material constants (μ_1, ε_1) and (μ_2, ε_2). Derive the complete expressions of the fields of the reflected and transmitted waves for the perpendicular polarization case. (25%)

4. Briefly answer the following questions. (5% each)

a. What is the meaning of the polarization of a plane wave?

b. What is the skin effect? Discuss your knowledge about the skin effect.

c. Discuss the concept of the distributed circuit as compared to a lumped circuit.

d. Discuss the reasons for transmission-line matching and the principle behind matching.

e. What is a Brewster angle? Why is it also called a polarizing angle?

光電工程導論

1 Please define or answer the following questions: (20%)

1.1 What is polarizer?

1.2 What is the definition of birefringence?

1.3 What is the Malus's law?

1.4 What is linear optical system?

1.5 What is the Huygens-Fresnel principle?

2 Single and multilayer films: (20%)

2.1 What is the condition for a single layer film to achieve anti-reflection coating for normal incident light? Assume the refractive index of air, substrate, and film is n_0, n_s, and n_1, respectively. The thickness of this single film is d.

2.2 What is the double-quarter, single-minimum coating? What is the condition to achieve such kind of coating?

3 Glass isosceles triangular prisms shown in Fig. 1 are used in optical instruments. Assuming $\varepsilon_r = 4$ for glass, calculate the percentage of the incident light power reflected back by the prism. (20%)

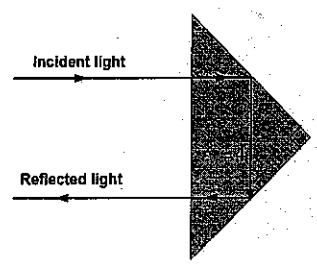


Fig. 1. Light reflection by a right isosceles triangular prism

4 For preventing interference of waves in neighboring fibers and for mechanical protection, individual optical fibers are usually cladded by a material of a lower refractive index, as shown in Fig. 4, where $n_2 < n_1$. (20%)

(a) Express the maximum angle of incidence θ_a in terms of n_0, n_1, and n_2 for meridional rays incident on the core's end face to be trapped inside the core by total internal reflection. (Meridional rays are those that pass through the fiber axis. The angle θ_a is called the acceptance angle, and $\sin\theta_a$ the numerical aperture (N.A) of the fiber.)

(b) Find θ_a and N.A. if $n_1 = 2$, $n_2 = 1.74$, and $n_0 = 1$.

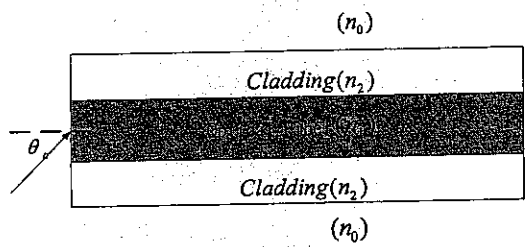


Fig. 4. A cladded-core optical fiber

5 Interferometer: (20%)

5.1 Please describe the setup of Mach-Zehnder interferometer and Sagnac interferometer?

5.2 Please compare their characteristics and differences?

國立中山大學九十一學年度博士班招生考試試題

科目：訊號與系統【電機系乙組】

Ph.D. Entrance Examination 2002

Signal and System (each problem : 25 points)

1. What is a LTIL system (Linear Time-Invariant Lumped System)? Clearly define each one of the key points.

2. If the input signal of a LTIL system is $x(t) = A[u(t) - u(t-T)]$ and the system impulse response $h(t) = B[u(t) - u(t-S)]$, where $u(t)$ is the unit-step function and A, B, S, T are constants, find the system output signal $y(t)$.

3. We can use differential equations to describe a system; on the other hand, we also can use system transfer function H(s) to do the same job. State your preferences and opinions on using these two kinds of methodologies, especially on their "completely characterization of the system"

4. Find the closed-form output sequence $y[k]$ of a discrete-time LTIL system satisfying the following state equations :

$$x[k+1] = A\,x[k] + B\,u[k],$$

$$y[k] = C\,x[k] + D\,u[k]$$

where $x[k]$, $u[k]$ and $y[k]$ are the state, input and output sequences of the system respectively, and { A, B, C, D } is the state description of a discrete LTIL system :

$$A = \{ a_{jk} \} : a_{11} = 0, \quad a_{12} = 1, \quad a_{21} = -2, \quad a_{22} = -3$$

$$B = \{ b_{jk} \} : b_{11} = 0, \quad b_{21} = 1$$

$$C = \{ c_{jk} \} : c_{11} = 1, \quad c_{12} = -1$$

$$D = \{ d_{jk} \} : d_{11} = 0$$