1. A $p^+ - n$ junction breakdown occurs at the electric field E_{crit}. Derive the expression of the breakdown voltage V_B the junction. (20%)

2. Derive the expression of the base transit time τ_t of a pnp bipolar junction transistor with base width W_B and carrier diffusion coefficient D_B.(20%)

3. Describe the Shockley-Read-Hall generation / recombination process.(20%)

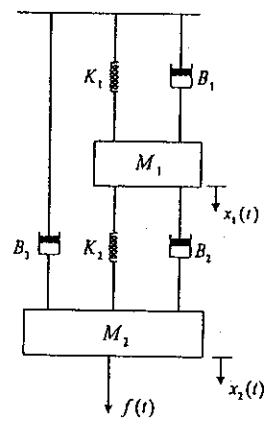
4. An NMOS capacitor has the work function difference ϕ_{ms} between the gate and the substrate and the interface charge density Q_{ss} at the junction between the oxide (SiO_2)and the substrate (Si). The substrate doping is N_A and the oxide thickness is t_{ox}. Derive the expression of the threshold voltage.(20%)

5. Derive the expressions of the capacitance for the MOS capacitor in problem 4.(20%)

國立中山大學九十二學年度博士班招生考試試題

科目：控制系統【電機系乙組】

1.(20%) Write the dynamic equations in standard state space form (let $z_1 = x_1$, $z_2 = \dot{x}_1$, $z_3 = x_2$, $z_4 = \dot{x}_2$) of the following mechanical system show below, where $K_1 = 6$, $B_1 = 5$, $M_1 = 10$, $K_2 = 4$, $B_2 = 3$, $B_3 = 2$, $M_2 = 15$.



2. The characteristic equation of a feedback control system is given by

$$s(s+3)(s^2+6s+64)+k=0$$

where $0 \le k \le \infty$. Use Root-Locus Technique to find

(a)(4%) pole(s) of the closed-loop system for $k = 0$ and $k = \infty$.

(b)(3%) the intersections(centroid) of the asymptotes.

(c)(3%) angle of the asymptotes.

(d)(5%) the angle of departure from one of the complex conjugate poles ($s = \sigma + j\omega$) corresponding to $k = 0$ and $\omega > 0$, and

(e)(6%) the intersection(s) of the root locus ($k \ge 0$) with the imaginary axis and the corresponding value(s) of k.

(f)(4%) sketch the root loci of the system.

3. Consider a control system with the loop transfer function

$$L(s) = \frac{K(1-s)}{s^2(s+1)}, \qquad K \ge 0$$

(a)(10%) Sketch the Nyquist Plot of this system for $K > 0$.

(b)(10%) Using Nyquist criterion, determine whether the closed-loop system is stable or not. 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 (use Nyquist criterion).

4. Consider a system whose Nichols chart is shown in the following.

(a)(2%) Find the maximum peak M_p in the closed-loop frequency response.

(b)(2%) Find the approximate resonance frequency ω_r?

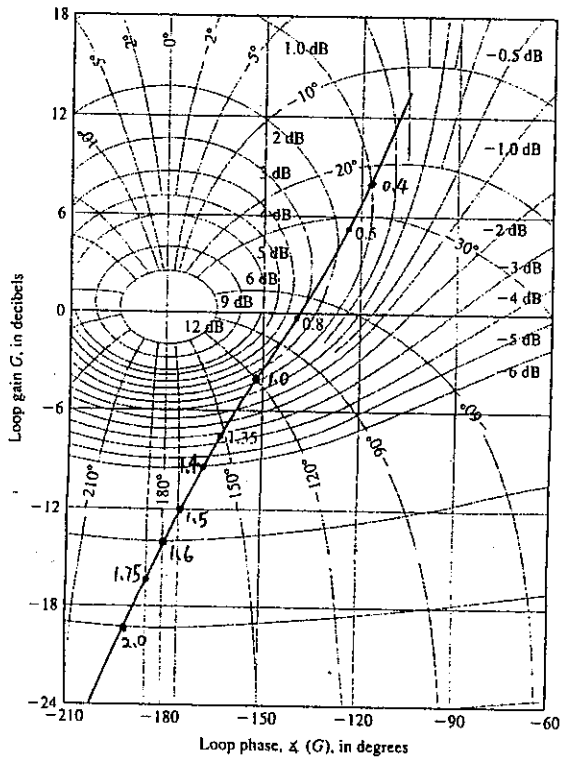
(c)(2%) Find the bandwidth of the closed-loop system.

(d)(4%) Find the phase crossover and gain crossover frequencies of this system.

(e)(4%) Find the phase margin and gain margin of this system.

(f)(3%) Find the closed-loop phase angles at ω_r.

(g)(6%) If the constant loop gain is increased to three times of the original system, is this system still stable? How much gain that you can increased to the original system before it become unstable?



5.(12%) Is the following Jordan-form dynamical equation controllable? observable? Explain the reason clearly.

$$\dot{x} = \begin{bmatrix} 7 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 7 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 7 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 7 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 9 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 9 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 9 \end{bmatrix} x + \begin{bmatrix} 0 & 0 & 0 \\ 2 & 1 & 1 \\ 1 & 0 & 1 \\ 3 & 2 & 1 \\ -1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} u$$

$$y = \begin{bmatrix} 2 & 0 & 1 & 3 & -1 & 1 & -1 \\ 1 & 0 & 1 & 2 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 1 \end{bmatrix} x$$

國立中山大學九十二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. (15%) Give a binary relation between 5 elements as following, compute its transitive closure.
   R = {(1,1), (1,2), (2,2), (2,4), (3,3), (3,5), (4,4), (4,5), (5,2), (5,5)}

2. (15%) From a population of 1,000 students of the same year in a university, if the birth rates of male and female of the year is 51% and 49%, what is the probability that there are 500 male and 500 female students exactly?

3. (20%) Write a subprogram to traverse a tree T(V,E) from its root node v_r to compute the sum of sizes of all its subtrees.

4. (30%) Given a **C++ program decomenting problem** :
   - at each new line, input characters (8-bit) are copied to the output
   - while recognizing the first '/' character, it is not copied to the output temporarily
   - while recognizing the second consecutive '/' character, all output is disabled until new-line character is read
   - while the second character after the first '/' does not match '/', the first '/' character and the second character are outputted
   - 8-bit ASCII codes for '/' and the new-line character are $2F_{16}$ and $0B_{16}$

   design a sequential circuit that performs de-commenting of a C++ program.
   (a) (15%) Draw its state transition diagram.
   (b) (15%) Design its sequential circuit implementation with D-type flip-flops.

5. (20%) In order to compute an inner product of two vectors A and B each of which is a 50-element vector, given a functional unit that can perform pipelined addition (2-cycle latency, 1-cycle issuing delay, and 1-cycle setup delay) and pipelined multiplication (8-cycle latency, 1-cycle issuing delay, and 1-cycle setup delay).
   (a) What is the **minimum** time we can use **one** such functional unit to compute the inner product?
   (b) What is the **minimum** time we can use **two** such functional units to compute the inner product?

國立中山大學九十二學年度博士班招生考試試題

科目：電力工程【電機系丁組】

1. Step by step, describe the procedure of solving a power system (with 99 busses) load flow problem by using Newton-Raphson method (25%).

2. Generally, an Equal-Area method is employed for analyzing the stability behavior of a single-machine power system, what is the main concern point of this "stability" problem (10%)? On the other hand, describe the analyzing procedure for solving a multi-machine power system stability problem (15%).

3. To control and analyze the electric machine (either rotary or linear) conveniently, a reference-frame transformation technique is generally introduced. For those widely using induction machines, describe the general idea and procedure of solving and controlling the machine system by applying the reference-frame transformation technique (20%).

4. Draw the functional block diagram of a power supply system inside a commercial personal computer, and describe how this system operates (25%).

國立中山大學九十二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」兩大部分，請任選一部分作答。

Electromagnetics

Entrance Examination for Ph. D. Program
June 15, 2003

1. Answering the following questions. (40%)

   (a) Write the differential form of the fundamental postulates of electrostatics and magnetostatics in free space.

   (b) Write the complete definition of *vector magnetic potential* $\vec{A}$.

   (c) What is the *electric dipole* and *magnetic dipole*?
   Write the definitions of electric dipole moment and magnetic dipole moment.

   (d) What is the *skin depth* of a conductor ?

   (e) What is meant by the *dispersion* of a signal?

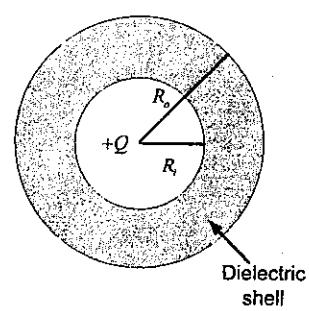
   (f) What is the *group velocity* and *phase velocity*? In what ways is group velocity different from phase velocity?

   (g) What is meant by a *cutoff frequency* of a waveguide?

   (h) What is the *radiation resistance* of an antenna?

2. A dipole antenna having an input impedance of 73(Ω) is fed by a 200(MHz) source through a 300(Ω) two-wire transmission line. Design a quarter-wave two-wire air line with a 2(cm) spacing to match the antenna to the 300(Ω) line. (20%)

3. A positive point charge Q is at the center of a spherical dielectric shell of an inner radius R_i and an outer radius R_o as shown in Fig. 1. The dielectric constant of the shell is ε_r. Determine E, V, D, and P as functions of the radial distance R in the regions of (a) $R > R_o$; (b) $R_i < R < R_o$; (c) $R < R_i$. (20%)



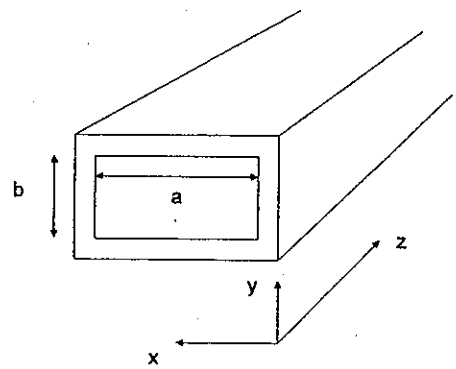
4. TM waves in rectangular waveguide: (20%)

   4.1 What is the definition of TM wave in the rectangular wavegude.

4.2 Derive the homogeneous Helmholtz's equations for E_z.

4.3 What are the boundary conditions for the equation in 4.2 ?

4.4 Solve the TM guided wave modes (field components) for this waveguide.



Optics Fundamental

1 Please define or answer the following questions: (30%)

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 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. 3, where $n_2 < n_1$. (30%)

(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 $n_0 = 1$.

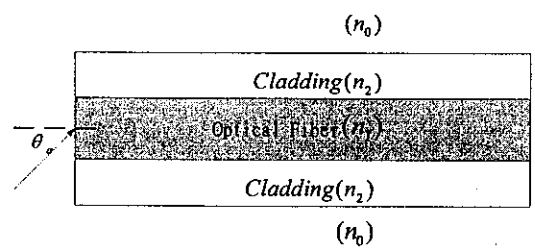


Fig. 3. A cladded-core optical fiber

4 Please describe the Fresnel-Arago laws. (20%)

Ph. D. Entrance Examination 2003 p1/1

Signals and Systems

(Problem 1, 2, 3 and 4 : 15 points each; Problem 5 and 6 : 20 points each)

1. If the impulse response h[k] = { 1, 2, 3, 4, -1, -2, ... }, and the input excitation u[k] = { 2, 1, -3, -2, -1, ... }, find the output response y[k] for k = 0, 1,..., 9, if the system is a Linear Time Invariant (LTI) lumped system.

2. If h[t] = 5, for 0 <= t <= 2 and h[t] = 0, for elsewhere; u[t] = 10, for 0 <= t <= 6 and u[t] = 0, for elsewhere, Find the describing equations of y[t] for all possible ranges of t and plot y[t] if the system is a LTI lumped system

3. Find the zero-state response of a system with the transfer function H(s) = 1/[s(s+2)], excited by the input u(t) = a*[q(t) - q(t-b)], where q(t) is the Unit step function. If a = 1, what is b in order for the response to reach 5 as t -> infinity; If b = 1, what is a in order for the response to reach 5 as t -> infinity.

4. Find the response of y(k) + y(k-1) - 2 y(k-2) = u(k-1) + 2 u(k-2) excited by y(-1) = -0.5, y(-2) = 0.25, and u(k) = 1, for k=0, 1, 2, ...

5. How do you derive discrete Fourier transform from continuous Fourier transform? What is fast Fourier transform, and why it is FAST?

6. Show that the discrete Fourier transform of a real sequence of length N is conjugate symmetric about the point at N/2