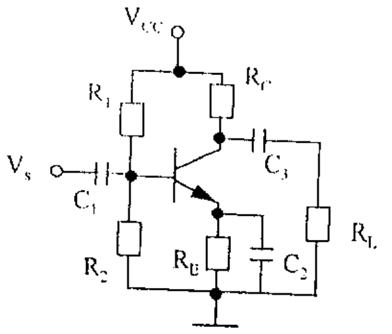
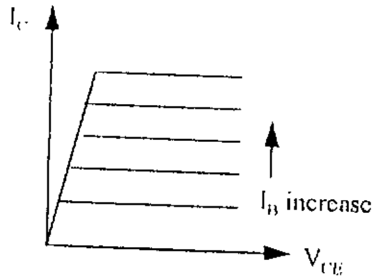
國立中山大學八十九學年度碩博士班招生考試試題

科　目：電子學（光電工程研究所）

Part I　　Questions:

1. Please describe the race-around condition of a J-K FLIP-FLOP. Can you avoid the condition? Please propose your idea. (10 %)
2. Please explain why an active load (current mirror) is used in place of the collector resistance in the interior stage of an Op-Amp? (8 %)
3. Please draw the DC and dynamic load lines of the amplifier stage given in the following? (7 %)





4. Please design an encoder, using multiple-emitter transistors, to satisfy the given truth table. (8 %)

Inputs			outputs				
w_1	w_2	w_3	Y_4	Y_3	Y_2	Y_1	Y_0
0	0	1	1	0	1	1	0
0	1	0	1	1	1	0	0
1	0	0	0	1	0	1	1

5. Please draw the two-port amplifier configuration of a shunt-shunt amplifier. Why the impedance levels (both the input and the output impedance) is low in this configuration? (10 %)
6. What is the Nyquist's criterion? Please draw the locus's on the Nyquist's plane for both a stable and a unstable systems. (7 %)

Part II　Problems:

1. Consider a step-graded pn junction shown in Fig. 1. Please draw the charge density ρ, field intensity E, potential variation V_j and minority carrier density as a function of distance x from the junction for both forward and reverse bias. Note that the depletion width must be indicated in your drawings. (10 %)

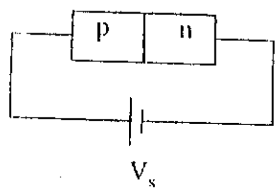


Fig. 1.

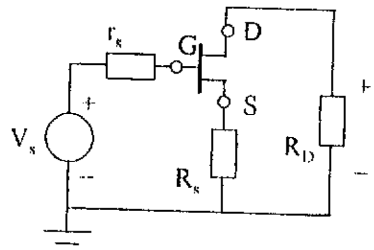
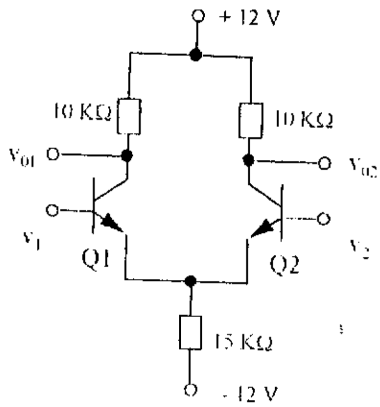


Fig. 2.

2. The circuit shown in Fig. 2 is a common-source amplifier with source resistance. The transconductance of the amplifier is g_m, and the drain and the source resistance of the FET are negligible. (a) Please draw the equivalent circuit of the amplifier without feedback. Note that we only need to consider the internal capacitor C_{gs} between gate (G) and source (S). (b) What is the return ratio T of the amplifier? (c) Please draw the normalized Bode plot (including the relative magnitude and phase to the relative frequency)of the transfer function of the circuit. What is the 3-dB frequency of the circuit? (20 %)

3. Consider the circuit shown in Fig. 3. (a) Please find the output voltages, v_{o1} and v_{o2}, when $v_1 = v_2 = 0$. (b) Please evaluate the A_{DM}, A_{CM} and CMRR of the circuit. The transconductance of the transistor is 20 mS. (20 %)



Institute of Electro-Optical Engineering
1996 Entrance Examination of *Engineering Mathematics*

Part I: Fill in the numbered blanks sequentially (60%).

In this session, each blank is worth 4%. You are not required to fill in any detail calculation. Just give the final result sequentially in the corresponding blank spaces in your answer sheet.

A. Under what condition: (1) , the equation $f(x)g(y)dx + h(x, y)dy = 0$ is *exact*.

B. Find the general solution of the following differential equations,

(i). when $(xD^2 - 3D)y = 0$, where D is an differential operator, then $y =$ (2) .

(ii). when $[D^2 - (\lambda_1 + \lambda_2)D + \lambda_1\lambda_2]\, y = ke^{px}$, then $y =$ (3) , if $\lambda_1 = \lambda_2 = p$.

C. Solve the problem, $\dfrac{\partial w}{\partial x} + x\dfrac{\partial w}{\partial t} = 0$, $w(x,0) = 0$, $w(0, t) = t$, for $t \geq 0$, then $w(x, t) =$ (4) .

D. Find the radius of convergence, R, of the power series $\displaystyle\sum_{m=0}^{\infty} \frac{(-1)^m}{k^m} x^{2m}$, $R =$ (5) .

E. The Sturm-Liouville problem described in the following: $y'' + \lambda y = 0$, $y(0) = 0$, $y'(l) = 0$, find the eigenvalues $\lambda =$ (6) , and the eigenfunctions $y_n =$ (7) , where $n = 0, 1, 2, \ldots\ldots$

F. One mapping is $w = \dfrac{2iz - 1}{z + 2i}$, find the fixed points: (8) .

G. Find the directional derivative, $\partial f/\partial s$, of $f(x, y, z) = x^2 + y^2 + z^2$ at the point P: (2, 2, 2) in the direction of the vector $\mathbf{a} = \mathbf{i} + 2\mathbf{j} - 3\mathbf{k}$, then $\partial f/\partial s =$ (9) .

H. If the eigenvalues of a square matrix A are $\lambda_1, \lambda_2, \ldots\ldots\lambda_n$, then the matrix $h(A - kI)^m$ (where h, k, and m are non-negative integers, and I is the unitary matrix) has the eigenvalues: (10) (in terms of $\lambda_1, \lambda_2, \ldots\ldots\lambda_n$).

I. Find the volume, V, of the tetrahedron with vectors **a**, **b**, **c** as adjacent edges where $\mathbf{a} = \mathbf{i} + 2\mathbf{k}$, $\mathbf{b} = 4\mathbf{i} + 6\mathbf{j} + 2\mathbf{k}$, $\mathbf{c} = 3\mathbf{i} + 3\mathbf{j} - 6\mathbf{k}$, then V = (11) .

J. Find the inverse Laplace transform of $y(t) = L^{-1}(Y(s)) =$ (12) , if $Y(s) = \dfrac{s}{(s-a)^{3/2}}$.

K. Find the solution of the Laplace equation in the disk of radius 1 with boundary values $f(\theta) = 10\cos^2\theta$. Solution = (13) .

L. Apply the divergence theorem to evaluate the integral $\iint_S e^{y}\,dz\,dx =$ (14) , where S: the surface of the parallelpiped $0 \le x \le 3, 0 \le y \le 2, 0 \le z \le 1$.

M. Apply Newton's iteration method to the equation $x^3 - 5x + 3 = 0$, starting from $x_0 = 2$ and performing 3 steps, then (15) $x_1 = ?\ x_2 = ?, x_3 = ?$.

Part II: 40%

In this session, each problem is worth 10%. You are required to provide the necessary details in order to get the full credit, and you should answer the problems in number sequentially in your answer sheet.

1. Explain the convolution theorem, then apply the theorem to solve the following initial value problem: $y'' + 2y = r(t)$, $r(t) = 1$ if $0 < t < 1$ and 0 if $t > 1$, $y(0) = 0$, $y'(0) = 0$.

2. Find the Fourier series of the periodic (2π) function $f(x) = x^2/4$ $(-\pi < x < \pi)$ and show that $1 - \frac{1}{4} + \frac{1}{9} - \frac{1}{16} + \ldots - \ldots = \frac{\pi^2}{12}$.

3. Explain the "Residue theorem", and apply the theorem to evaluate the following integral $\int_C \frac{\cosh 2z}{z^4 + 16}\,dz$, where z is a complex variable and C is the unit circle (counterclockwise).

4. Describe the "Green's Theorem", and apply the theorem to evaluate the line integral $\int_C 2xy^3\,dx + 3x^2y^2\,dy$ counterclockwise around the contour C: $x^2 + y^2 = 1$.

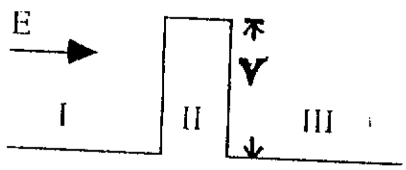
1. In a photoelectric experiment in which monochromatic light and a sodium photo cathode are used. Stopping potentials of 1.85 V for $\lambda = 0.3$ μm and 0.82 V for $\lambda = 0.4$ μm are found. From these data determine
   (i) a value for Plank's constant, 7%
   (ii) the work function of sodium in electron volts, and 7%
   (iii) the threshold wavelength for sodium. 6%

2. Consider a X-ray beam, with $\lambda = 2.00$ Å and also a γ-ray beam with $\lambda = 0.02$ Å. If the radiation scattered from free electrons is viewed at 90 degrees to the incident beam,
   (i) What is the Compton wavelength shift in each case ? 6%
   (ii) What kinetic energy is given to a recoiling electron in each case ? 7%
   (iii) What percentage of the incident photon energy is lost in the collision in each case ? 7%

3. What is the maximum speed for which the classical expression $\frac{1}{2}mv^2$ will yield an error in the kinetic energy no greater than 5 % ? 10%

4. Write down the Schroedinger's equation for a simple harmonic oscillator. 15%

5. Consider a potential barrier (V) shown below, a particle with total energy E incident from the left with E < V. Qualitatively draw its wave funtions in regions I, II, and III. 15%



6. Explain the following terms,
   (i) Zeeman effect 10%
   (ii) Fermi probability distribution 10%

Institute of Electro-Optical Engineering
1996 Entrance Exam. Electromagnetism

Part I: Fill in the blanks (60%)

In this session, each blank is worth 5%. Please do your calculation on the scratch paper and copy the final result in the corresponding blank space in your answer sheet. For those problems that require numerical values, try to give your best estimates. You shall get full credit if your answer is within 80% accuracy. Partial credit is also awarded if your answer is not too far off. For problems e, h and j, you get full credit only if you write your answer in less than 25 words in English or Chinese.

a The four fundamental electromagnetic field quantities are $\vec{E}$, $\vec{D}$, $\vec{B}$, $\vec{H}$ fields. Please give their names ____(1)____ and units ____(2)____ (in MKS system).

b State the necessary and sufficient condition for a conservative electric field $\vec{E}(r)$: ____(3)____.

c Simplify the following vector identities: 1) $\vec{a}\times(\vec{b}\times\vec{c}) =$ ____(4)____ where $\vec{a}, \vec{b}, \vec{c}$ are vectors and $\nabla\cdot(\phi\vec{A}) =$ ____(5)____ where ϕ is a scalar function and $\vec{A}$ is a vector function.

d Write down the two interface conditions for the time-varying electromagnetic fields ____(6)____ as required by Farady's Law, and Ampere's Law.

e Why the sky is blue in a cloudless daytime? A: ____(7)____.

f Give the operating frequencies of the following waveguides 1) coaxial cable used in the CATV system, 2) optical fiber used in the long distance telephone communication system. A: ____(8)____. (Units are required for your answer)

g Determine the lowest cut-off frequency for the coaxial cable carrying TEM (transverse EM) waves: ____(9)____ assuming that the inner/outer radii $r_1 = 0.05$ cm, and $r_2 = 0.5$ cm and the characteristic impedance is 50 Ω.

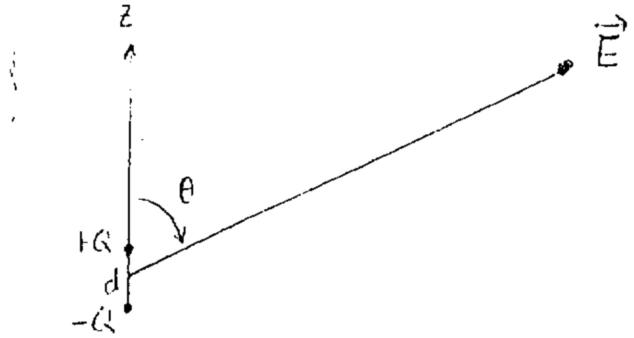
h State the guiding principle and the what type of waves (e.g. TEM, TE, TM, etc.) exist in the optical fiber: A: ____(10)____.

i Give the typical values of condutivities σ of 1) an insulator (pure silica), 2) the silver metal. A: ____(11)____.

j Describe the EM wave characteristics of a Gaussian beam generated by a laser source. A: ____(12)____.

Part II: 40%

1 Derive the far field $\vec{E}$ field formular of an electrical dipole (pair of equal but oppositely charged particles) located on z axis. The dipole moment is assumed to be $Qd\hat{z}$. Please express your solution in the spherical coordinate system. (10%)



2 Derive one-dimensional Helmholtz' equation from Maxwell's equations for the x-component $\vec{E}$ field propagating in the z direction. (15%)

2 Derive the transmission coefficient of the normally incident plane wave upon a slab of thickness d and index of refraction n. Assume that the wave is propagating in the z direction and both sides of the slab are vacuum. (15%)