國立中山大學９６學年度碩士班招生考試試題

科目：工程數學【光電所碩士班】

1. Please solve the initial value problem.

$(D^4+4D^3+8D^2+8D+4)y=0, y(0)=1, y'(0)=0, y''(0)=-2, y'''(0)=2$

$(D^{(n)}=\frac{d^n}{dx^n})$ (15%)

2. Please solve the differential equation. (15%)

$x(x-1)y''+(3x-1)y'+y=0$

3. Please evaluate the following integrals.

(a) $\int_0^{\pi}\frac{d\theta}{(a+\cos\theta)^2}$ $(a>1)$ (5%)

(b) $\int_C\frac{3z^3+2}{(z-1)(z^2+9)}dz$, taken counterclockwise around the circle $|z-2|=2$ (10%)

4. Find the center and the radius of convergence of the following power series.

(a) $\sum_{n=0}^{\infty}(\frac{4-2i}{1+5i})^n z^n$ (5%) (b) $3^2z^2+z^3+3^4z^4+z^5+3^6z^6+z^7+\ldots$ (5%)

5. Find the Taylor series of the following function with center z_0=1. (15%)

$f(z)=\frac{2z^2+9z+5}{z^3+z^2-8z-12}$

6. In an experiment to monitor two calls, the Probability Mass Function (PMF) of N the number of voice calls, is

$$P_N(n)=\begin{cases}0.1 & n=0\\ 0.4 & n=1\\ 0.5 & n=2\\ 0 & otherwise\end{cases}$$ Please find

(a) The mean square value $E[N^2]$ (5%) (b) The standard deviation σ_N (5%)

7. Fit a straight line to the given points (x,y) by the method of least squares. (Ohm's law : U=R*i*) Estimate R from the least squares line that fits the following data. (*i*,U)=(3.0, 162), (5.0, 255), (7.0, 360), (10.0, 495). (10%)

8. Solve the following linear system by Gauss elimination. (10%)

$2x_1+5x_2+7x_3=25$

國立中山大學９６學年度碩士班招生考試試題

科目：電磁學【光電所碩士班】

2007 Institute of Electro-Optical Engineering, Nsysu

1. A) Write down the time-dependent and time-harmonic Maxwell equations in differential for linear isotropic non-dispersive media. For EM waves in linear dispersive dielectric materials, the time-dependent and time-harmonic Maxwell equations are quite different. B) State the differences between these two set of Maxwell equations and discuss when and how they are used. (20%)

2. A) Prove that in a Cartesian coordinate that a double curled vector field function $\overline{F}$ can be expression as sum of a vector Laplacian and gradient of the divergence of the original function. Please also determine the two constants c_1, c_2.

$$\nabla\times\left(\nabla\times\overline{F}\right)=c_1\nabla^2\overline{F}+c_2\nabla\left(\nabla\cdot\overline{F}\right)$$

B) Using Maxwell equations and a few vector identities we may derive the one-dimensional vector wave equation for a plane EM wave in free space (you do not need to show this). Discuss and show weather or not it is possible to have z-component electric and/or magnetic fields for a 1-D EM plane wave to propagate along the z-direction. (20%)

3. Outline how EM wave theories (Gauss' Law, Ampere's Law, Faraday's Law, quasi-static EM analysis, etc.) are applied to explain how low-frequency electro-mechanical generators work (50-60 Hz). Note that full EM wave theory is not needed to model the electric motors, unless we are studying/ explaining electric power radiation to the outer space. (20%)

4. In modern communication systems, optical fibers are used to guide the EM wave signals modulating optical carriers in the near infrared region. A power level of 0 dBm is equal to 1 milliwatt (0.1% of one watt). Estimate how many photons are transmitted per second inside an optical fiber with 10dBm of input optical power level. For this calculation, you need to make one more assumption and know the numerical value of several key physical constants. You may express your estimate in term of a mathematical expression but only those with knowledge of numerical constant will get full credit. (20%)

5. Consider a parallel-plate waveguide made of two perfectly conducting metal sheets separated by a distance d in free space. For 2D $u_y(x,z)$ waves propagating along z direction, derive the boundary conditions for both TE ($u_y(x,z)=E_y$) and TM ($u_y(x,z)=H_y$) waves in time-harmonic case. Show that fundamental TM mode does not have a cut-off frequency but the fundamental TE mode has one a cut-off frequency. Please also calculate this TE mode cut-off frequency. (20%)

國立中山大學９６學年度碩士班招生考試試題

科目：電子學【光電所碩士班選考】

電子學(選考) 光電工程研究所碩士班

(15points)

(1) (a) Explain and compare the functions of BJT and FET.
(b) Please draw the cross section view of a CMOS. You should indicate the p-MOS-FET, n-MOS-FET, the substrate and their interconnections.
(c) Please define the drift current and diffusion current in semiconductors.

(20 points)

(2) A PN diode is driven by a bias.
(a) Explain why there is a depletion region formed in the junction of a PN diode.
(b) A step graded PN junction with permittivity of ε has width of W and Nd (donor level) in n- region and Na (acceptor level) in p- region. Please derive the built-in voltage and the capacitance of a PN junction if Nd >> Na. Also, please draw schematic diagrams for charge density, electric field density, and electrostatic potential in the junction.
(c) Draw the schematic current-voltage (*I-V*) relation in forward- and reverse-biased PN junction. And explain what the mechanism causing the major portion of current in forward bias is. In the plot, you should indicate the voltage polarization, the turn voltage, the breakdown voltage, and dark current level of a PN diode.

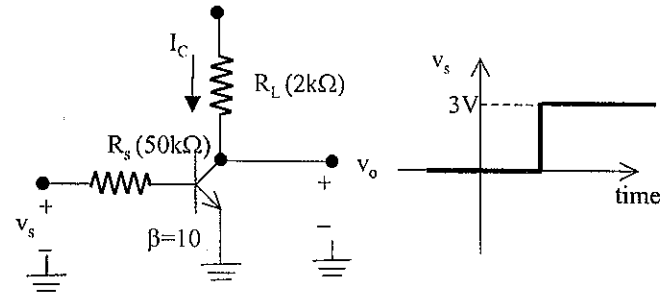

Figure 1

(25 points)

(3) The circuit in figure1 is a common-emitter BJT serving as switching and "INVERT" logic gate.
(a)Please draw the large-signal D.C. equivalent circuits with explanation.
(b)Please plot the output characteristics of v_o and Ic with time. You should calculate the v_o and Ic levels before and after switching.
(c)If all the circuit elements surrounding the BJT is fast enough, then what are the factors determining the switching speed? You could use the plots in (b) to state your answer.
(d) Please explain why this circuit can be used as inverter.

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(20 points)

(4) A current mirror source is shown in figure 2.

(a)Please explain the function of this current mirror. You could assume R_2=0Ω and two transistors are identical.

(b)Please explain the function of R_2.

(c) If two transistors are identical, please derive R_2 in terms of V_T (volt equivalent of temperature), I_{C1}, I_{C2} and β.

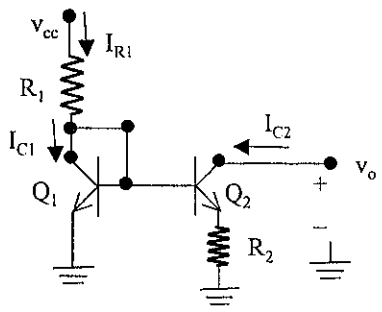

Figure 2

(20 points)

(5) A nonideal inverting OP-amplifier is shown in figure 3. The OP-amplifier has A_v =10^5 (voltage gain), R_i=1MΩ (input resistance) and R_o=400Ω (output resistance). Please find the voltage gain (v_o/v_i). And also, find the ideal inverting OP-amplifier gain.

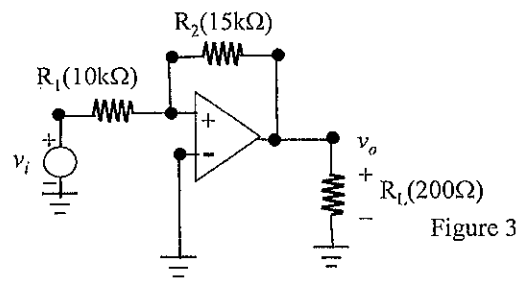

Figure 3

國立中山大學９６學年度碩士班招生考試試題

科目：近代物理【光電所碩士班選考】

1. The electronic configuration of aluminum at ground state is $1s^2\,2s^2\,2p^6\,3s^2\,3p^1$. Please draw schematically the filling of electronic states. (5%)

2. A baseball of mass 140 g traveled at a speed of 115 km/h. What was the wavelength of the baseball? (5%)

3. The intensity of a beam of UV radiation is halved when it passes through a sheet of glass of thickness 9 mm. What thickness of glass would be needed to reduce the beam's intensity to just 1 % of its original value? (10%)

4. When a sodium atom which emitting at 589.50 nm is moving towards you at a speed $u = 6.89 \times 10^{5}$ m/s, what wavelength of the emitting light beam can be measured? (10%)

5. The rest mass of a particle is 1.66×10^{-27} kg. (a) If the particle is accelerated to gain the speed of light c, what is the rest mass of the particle? (b) The particle traveling at the speed of light is measured to have energy of 5MeV. If the particle and a photon with energy 2 MeV are approaching each other along the x axis, what is the rest energy of the two-particle system? (20%)

6. Solar radiation falls on the earth at a rate of 2.0 cal/cm^2·min. The radiation is incident normally on a perfectly reflecting mirror of diameter 8.8 m. Calculate, from classical considerations, the force exerted on the mirror. (10%)

7. A particle is confined between rigid walls separated by a distance l. The wave function for the particle can be written as

$$\Psi = A\sin\frac{n\pi x}{l}.$$

   (a) What is the probability that it will be found within a distance $\frac{l}{3}$ from one wall for n =1 and n=2, respectively?

   (b) If the particle's mass $m = 1.0\text{x}10^{-9}$ kg, it moves at the speed $u = 10^{-6}$ m/s between rigid walls, and $l = 10^{-4}$ m, what quantum number describes this motion? (20%)

8. For a microscope the smallest detail that can be separated is about equal to the wavelength. Suppose one wishes to "see" inside an atom. Assuming the atom to have a diameter of 0.10 nm, this means that we wish to resolve detail of separation about 0.010 nm. (a) If an electron microscope is used, what minimum energy of electrons is needed? (b) If an optical microscope is used, what minimum energy of photons is needed? (20%)

Useful Constants

$h = 6.626 \times 10^{-34}\ J\cdot s$

Electron rest mass: $m_e = 9.109 \times 10^{-31}\ kg$

$1eV = 16.10 \times 10^{-19}\ J$

1 cal = 4.18 J