國立中山大學九十學年度碩博士班招生考試試題

科目：電子學【通訊所碩士班】

1. Consider the Zener diode circuit shown in Figure 1. The Zener breakdown voltage is $V_Z = 5.6V$ at $I_Z = 0.1mA$, and the incremental Zener resistance is $r_z = 10\Omega$. (a) Determine V_0 with no load ($R_L = \infty$). (b) Find the change in the output voltage if V_{PS} changes by $\pm 1V$. (c) Find V_0 if $V_{PS} = 10V$ and $R_L = 2k\Omega$. (12%)

2. The parameters of the transistor in the circuit shown in Figure 2, are $\beta = 150$ and $V_A = \infty$. (a) Determine R_1 and R_2 to obtain a bias-stable circuit with the Q-point in the center of the load line. (b) Determine the small-signal voltage gain $A_V = v_o / v_s$. (12%)

3. The equivalent circuit shown in Figure 3 has circuit parameters $R_S = 1k\Omega$, $r_\pi = 2.6k\Omega$, $g_m = 38.5mA/V$, and $R_L = 5k\Omega$. (a) Derive the expression for the voltage transfer function $T(s) = V_0(s)/V_i(s)$. (b) Determine the required value of C_L such that the 3dB frequency is 500 kHz. (c) What is the maximum gain asymptote? (d) Sketch the Bode plot of the voltage transfer function magnitude and phase. (16%)

4. Consider the instrumentation amplifier shown in Figure 4. The circuit parameters are: $R_1 = 10k\Omega$, $R_2 = 50k\Omega$, $R_3 = 20k\Omega$, and $R_4 = 30k\Omega$. Let $V_{I2} = 25\sin\omega t$ mV and $V_{I1} = -25\sin\omega t$ mV. Find v_{O1}, v_{O2}, v_O, and the current in each resistor. (12%)

5. The transistor parameters for the circuit shown in Figure 5 are: $\beta = 100$, $V_{BE}(on) = 0.7V$, and $V_A = \infty$. (a) Determine R_E such that $I_E = 150\mu A$. (b) Find A_d, A_{cm}, and $CMRR_{dB}$ for a one-sided output at V_{O2}. (c) Determine the differential- and common-mode input resistances. (15%)

6. For the op-amp shown in Figure 6, the input offset voltage is $V_{OS} = 10$ mV, the input bias current is $I_B = 2\mu A$, and the input offset current is $I_{OS} = 0.2\mu A$. (a) Determine the worst-case, or maximum, output voltage when $V_I = 0$. (b) Design compensation circuit(s) to minimize v_O when $v_I = 0$. (12%)

7. Consider the Schmitt trigger shown in Figure 7. Assume the saturated output voltages are $\pm V_P$. (a) Derive the expression for the crossover voltages V_{TH} and V_{TL}. (b) Let $R_A = 10k\Omega$, $R_B = 20k\Omega$, $R_1 = 5k\Omega$, $R_2 = 20k\Omega$, $V_P = 10$ V, and $V_{REF} = 2$ V. (a) Find V_{TH} and V_{TL}. (b) Sketch the voltage transfer characteristics. (12%)

8. Describe the specialized characteristics of the following diodes: (a) Schottky barrier diode; (b) light-emitting diode; and (c) photodiode. (9%)

國立中山大學九十學年度碩博士班招生考試試題

科目： 電子學【通訊所碩士班】

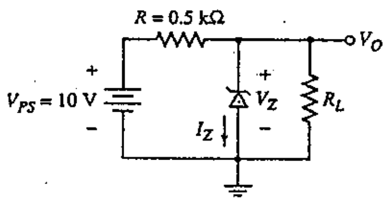

Figure 1

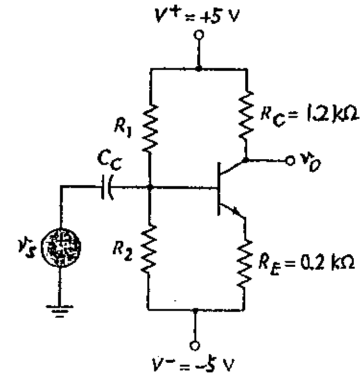

Figure 2

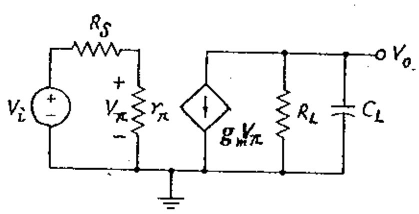

Figure 3

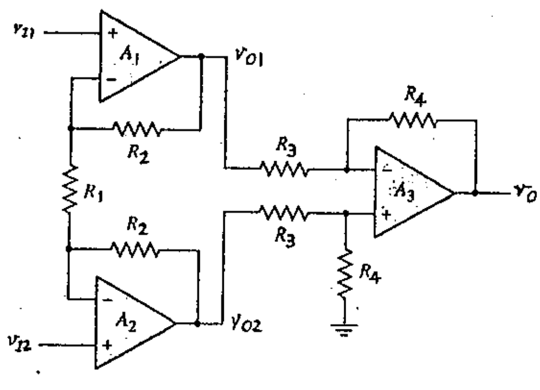

Figure 4

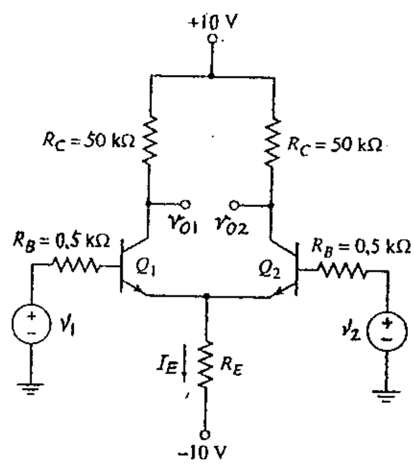

Figure 5

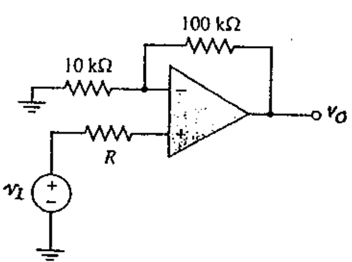

Figure 6

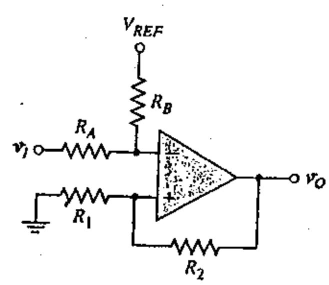

Figure 7

國立中山大學九十學年度碩博士班招生考試試題

科目：工程數學【通訊所碩士班】甲組

計分說明:

本題計分將採用一種新創的"市場需求調整計分法",即計分高低(價值)與獲解率(市場需求率之倒數，愈易獲解，市場上需求愈低)成反比。所以考生除了要把握多數人會的題目外，還要著重於自己獨特的能力，即別人不容易會的問題。 在入學徵才錄取率不高的情況下，希望考生能發揮出自己卓越的特點。

你的得分($S_1', S_2', S_3'\ldots.$)公式計算如下：令$R_1, R_2, R_3, \ldots$爲小題各自原始分數給分範圍，$R_1', R_2', R_3'\ldots.$爲依市場需求調整後的分數給分範圍，$M_1, M_2, M_3, \ldots.$爲小題各自的原始平均得分，$S_1, S_2, S_3, \ldots.$ 爲小題各自原始得分：

則$S_1' = S_1 \times \dfrac{R_1'}{R_1}$

而$R_1', R_2', R_3', \ldots.$的計算，在$M_1, M_2, M_3, \ldots.$的各小題平均分數算出後，

依據$R_1' : R_2' : R_3', \ldots. = \dfrac{R_1}{M_1} : \dfrac{R_2}{M_2} : \dfrac{R_3}{M_3}, \ldots.$得到，且$R_1' + R_2' + R_3', \ldots. = 100$

注意$R_1, R_2, R_3, \ldots.$的原始範圍可以任意設定，爲著讓考生易所依循，我仍可以做一次不必要的設定：$R_1 = R_2 = R_3, \ldots. = \dfrac{100}{6}$。

1. Give an example to explain the probability measure should not be assigned to the outcomes in the sample space.

2. An urn (類似一個黑色罐子) contains b black and r red balls. The ball is drawn at random without replacement until the first white ball is extracted. What is the expectation of the number of the extracted black balls? Please give the exact answer. (Hint: Do not use the probability density for the number of the extracted black balls or you will get a messy answer. Think about the relation of some expectations of some useful random variables.)

3. Describe how the idea of inner product for vectors is applied to the concept of correlation of random variables in probability theory.

4. Prove or disprove by counter example that orthogonality implies linear independence in the linear space.

5. What is the dimension of the possible linear space of the real field over the complex field if it is a space? Explain in detail.

6. What are the eigenvectors of a rotation transformation in the real plane?

國立中山大學九十學年度碩博士班招生考試試題

科目：通訊系統【通訊所碩士班】甲組

10 points for each of the 10 questions. Be concise and complete !

1. Define "noise figure" and derive "cascaded noise figure" of 3 stages with noise figures F_1, F_2, F_3 and gains G_1, G_2, G_3.

2. Define "linear time-invariant lumped system" and show that the output response of this system is the convolution of the input excitation and the system impulse response function.

3. Define "additive white Gaussian noise – AWGN ". How can we generate AWGN samples ? Explain your confirmation procedures.

4. Derive "Bayes' decision rule", "maximum a posteriori decision rule" and "maximum likelihood decision rule".

5. What are "Wiener filter " and "matched filter" ? Why do we use these filters and how ?

6. What is "signal companding" ? Why do we use it and how ?

7. What is "Gram-Schmidt procedure" ? Why do we use it and how ?

8. What is "spread spectrum communication system" ? Why do we use it and how ?

9. A pre-emphasis/de-emphasis system is to be designed to work with noise having a spectral density

$$S_n(f) = \exp(5 * 10^{-4} |f|), \quad V^2/Hz$$

The de-emphasis filter is designed to whiten the noise spectral density over the range of 0 ~ 15 kHz. Find the power transfer function of the pre-emphasis filter required to prevent signal distortion. What SNR improvement can be obtained with this system as compared with a system with no pre-emphasis/de-emphasis ?

10. A binary communication system uses antipodal signals of the form

$$s_i(t) = (-1)^i [\, 1 - \cos(2 * 3.1416 * t / T)\,], \quad 0 \le t \le T, \quad i = 0, 1$$

And the two signals are equally probable. These signals are received in the presence of non-white noise having a two-sided spectral density of

$$S_{nb}(w) = 8*10^4 / (w^2 + 4*10^{10})$$

The bit rate is 30,000 bits / sec.

(a) Find the transfer function of the whitening filter that is needed.
(b) Find the impulse response of the matched filter that follows the whitening filter.

1. (20pts) We would like to solve the differential equation
   $$y''(t)+2y'(t)+y(t)=x(t),\ \ y'(0)=0,\ \ y(0)=1.$$
   (a) Find the natural response due to the initial conditions alone, i.e., $x(t)=0$.
   (b) Find the forced response for a given input $x(t)=\sin t$ with zero initial conditions.

2. (20pts) Consider the partial differential equation
   $$\frac{\partial^2 u}{\partial z^2}-\frac{\partial^2 u}{\partial t^2}=0.$$
   (a) Show that $u(z,t)=f(az-t)$, $a>0$, is a solution and determine the constant a.
   (b) If the function $f(\cdot)$ is a Gaussian pulse $f(x)=\exp(-x^2)$, can this function be a solution to the equation? Why?
   (c) Suppose the solution $f(\cdot)$ is sinusoidal, e.g., $f(x)=\cos x$. Does the position of a peak of $u(z,t)=f(az-t)$ move as the time increases? If so, what is the speed?
   (d) It can be shown that a complete solution is $u(z,t)=f(az-t)+g(az+t)$. If $f(x)=g(x)=\cos x$, does the position of the minimum $|u(z,t)|$ move as the time increases? If so, what is the speed?

3. (15pts) The Laplace's equation in Cartesian coordinates and cylindrical coordinates $x=\rho\cos\phi$, $y=\rho\sin\phi$ are
   $$\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}=\frac{\partial^2 u}{\partial \rho^2}+\frac{1}{\rho}\frac{\partial u}{\partial \rho}+\frac{1}{\rho^2}\frac{\partial^2 u}{\partial \phi^2}=0.$$
   We will carry out the derivation only partially.
   (a) Write $\frac{\partial u}{\partial x}=A\frac{\partial u}{\partial \rho}+B\frac{\partial u}{\partial \phi}$. Find A and B. (5pts)
   (b) Express $\frac{\partial^2 u}{\partial x^2}$ in terms of the derivatives of u with respect to ρ and ϕ. (10pts).

4. (15pts) A helix is described by $\vec{r}(t)=\vec{a}_x 2\cos(t/2)+\vec{a}_y 2\sin(t/2)+\vec{a}_z t$.
   (a) Write $d\vec{r}(t)=\vec{A}(t)dt$. Determine the vector $\vec{A}(t)$. (5pts)
   (b) Find a unit tangent to the curve at $(2,0,0)$. (5pts)
   (c) Find the length of the curve from $(2,0,0)$ to $(0,2,\pi)$. (5pts)

5. (15pts) The directional derivative of a function $\phi(x,y)$ at (x_0, y_0) in the direction of a unit vector $\vec{a}_u = \vec{a}_x u_x + \vec{a}_y u_y$ is defined by

$$\frac{d\phi}{d\vec{a}_u} \triangleq \lim_{h\to 0} \frac{\phi(x_0 + hu_x, y_0 + hu_y) - \phi(x_0, y_0)}{h}.$$

Express this quantity in terms of $\vec{a}_u$ and $\nabla\phi(x_0, y_0)$. Show your derivation.

6. (15pts) Verify Stoke's theorem for the vector field $\vec{F}(x,y,z) = \vec{a}_x x + \vec{a}_y x + \vec{a}_z 2xy$ using the hemisphere $x^2 + y^2 + z^2 = 4$, $z < 0$.

(a) Compute $\nabla \times \vec{F}(x,y,z)$. (5pts)

(b) Perform the line integral. (5pts)

(c) Perform the surface integral. (5pts)

國立中山大學九十學年度碩博士班招生考試試題

科目：電磁學【通訊所碩士班】乙組

1.(20%) A capacitor consists of two coaxial metallic cylindrical surfaces of a length 30 (mm) and radii 5 (mm) and 7 (mm). The dielectric material between the surfaces has a relative permittivity $\epsilon_r = 2 + \frac{4}{r}$, where r is measured in mm. Determine the capacitance of the capacitor.

2.(20%) An air coaxial transmission line has a solid inner conductor of radius a and an outer conductor of radius b and thickness d. Determine the inductance per unit length in terms of a, b, d for the line.

3. A right-hand circularly polarized wave represented by the phasor $\vec{E}(z) = E_0(\hat{a}_x - j\hat{a}_y)e^{-j\beta z}$ is incident normally from air onto a perfect conducting wall at $z = 0$.

(a).(10%) Determine the polarization of the reflected wave.

(b).(10%) Find the induced current on the conducting wall.

4. The open-circuit and short-circuit impedances measured at the input terminals of an air-spaced transmission line 4 (m) long are $250\angle -50°(\Omega)$ and $360\angle 20°(\Omega)$, respectively.

(a).(10%) Determine Z_0, α and β of the line.

(b).(10%) Determine R, L, G, and C.

5.(20%) The power handling capacity of an air-filled waveguide is limited by voltage breakdown, which occurs at a field strength of about 3×10^6 (V/m) for room temperature air at sea level pressure. Find the maximum amount of 10 (GHz) average power that can be transmitted through an air-filled rectangular waveguide with dimension $a = 2.25$ (cm) and $b = 1.00$ (cm) at the TE_{10} mode without a breakdown.