國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：工程數學甲【電機系碩士班甲組、戊組選考、己組、庚組、通訊所碩士班乙組選考、電波聯合碩士班選考】

－作答注意事項－

考試時間：100分鐘

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- **違規者依本校招生考試試場規則及違規處理辦法處理。**

國立中山大學112學年度碩士班暨碩士在職專班招生考試試題

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※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（混合題）

下面第1-2題為單選題，總分10分。每題答對5分，答錯扣5分，未作答者以0分計。兩題總分低於零分者以零分計算。

1. Which of the following is true about the initial value problem of $y''' - 2y'' + y' = xe^x + 5$ with $y(0) = 2, y'(0) = 2$ and $y''(0) = -1$? Assume that the particular solution $y_p = A_1x^{B_1}e^{C_1x} + A_2x^{B_2}e^{C_2x} + A_3x^{B_3}e^{C_3x} + A_4x^{B_4}e^{C_4x}$.
   (A) $\sum_{i=1}^{4}(A_i + B_i + C_i) = 41/3$.
   (B) $\sum_{i=1}^{4}(A_i + B_i + C_i) = 5$
   (C) $\sum_{i=1}^{4}(A_i + B_i + C_i) = 38/3$.
   (D) $\sum_{i=1}^{4}(A_i + B_i + C_i) = 14/3$.
   (E) $\sum_{i=1}^{4}(A_i + B_i + C_i) = 8$.

2. The points **A**$(1, -2, 1)$, **B**$(0, 1, 6)$, and **C**$(-3, 4, -2)$ form a triangle. Find the angle (°) between the line **AB** and the line from **A** to the midpoint of the line **BC**. (Numbers are rounded to 2 decimal places).
   (A) 81.29°　(B) 121.51°　(C) 33.89°　(D) 47.40°　(E) 0.83°

下面第3-13題為複選題，每題5分，總分55分，每題有5個選項，其中至少有1個是正確答案，答錯1個選項者，得3分，答錯2個選項者，得1分，答錯多於2個選項或未作答者，該題以零分計算。

3. Which of the following is/are linear differential equation(s)?
   (A) $xy'' + (\sin x)y = 0$
   (B) $y'' + 5xy' + \sqrt{xy} = 0$
   (C) $\frac{d^2x}{dt^2} = t + x^2$
   (D) $\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} = u$
   (E) $t^2x'' - 4tx' + 6x = \ln t^2$

4. Consider the differential equation $(t-4)^2x'' - 5(t-4)x' = -9x$, which of the following is/are correct?
   (A) It's an autonomous differential equation.
   (B) The general solution is $x = c_1t^3 + c_2t^3 \ln t$.
   (C) $t = 4$ is a regular singular point.
   (D) The interval of definition of the general solution is $(0, \infty)$.
   (E) The interval of definition of the general solution is $(-\infty, \infty)$.

5. Consider the Laplace's equation $u_{xx} + u_{yy} = 0$ with the conditions listed below. According to the boundary conditions, it's possible to reduce the Laplace's equation into two simultaneous equations with respect to x and y, separately. Assume λ is the eigenvalue, identify the correct statements.

$$\begin{cases} u(0,y) = 0, & u(L,y) = 0 \quad 0 < y < H \\ u(x,0) = f(x), & u(x,H) = 0 \quad 0 < x < L \end{cases}$$

(A) The Laplace's equation is elliptic.
(B) This question is a Dirichlet problem.
(C) The problem for X is $X'' - \lambda X = 0, X(0) = 0, X(L) = 0$.
(D) The problem for Y is $Y'' + \lambda Y = 0, Y(H) = f(0)$.
(E) The problem for Y is $Y'' + \lambda Y = 0, Y(H) = 0$.

6. Following question 5, which of the following is/are correct?
(A) $\lambda = \frac{n\pi}{L}, X(x) = \sin\left(\frac{n\pi x}{L}\right), n = 1,2,3, \ldots$
(B) $\lambda = \left(\frac{n\pi}{L}\right)^2, X(x) = \sin\left(\frac{n\pi x}{L}\right), n = 1,2,3, \ldots$
(C) $\lambda = \frac{n\pi}{H}, X(x) = \sin\left(\frac{n\pi x}{H}\right), n = 0,1,2, \ldots$
(D) The product solution is $\sin\left(\frac{n\pi x}{H}\right)\cosh\left(-\frac{n\pi(y-L)}{H}\right)$.
(E) The product solution is $\sin\left(\frac{n\pi x}{L}\right)\sinh\left(\frac{n\pi(y-H)}{L}\right)$.

7. Which of the following is/are true about the differential equation, $y' + 2y^2 - 3y + 1 = 0$?
(A) It is a second-order homogeneous differential equation.
(B) There are two critical points.
(C) One of the critical points is an attractor.
(D) None of the critical points is an attractor.
(E) The solution $y(x)$ increases with x when x is defined on $(1/2, \infty)$.

8. Consider the linear system $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3] \in \mathbb{R}^{5\times3}$, $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are column vectors of $\mathbf{A}$, and $\mathbf{b}$ is a non-zero vector. Suppose $\mathbf{b} = \mathbf{a}_1 + \mathbf{a}_2 = 2\mathbf{a}_2 + \mathbf{a}_3$. Which of the following statements are true?
(A) The linear system has exactly two solutions.
(B) The linear system has at most two solutions.
(C) $\text{rank}([\mathbf{A}, \mathbf{b}]) = \text{rank}(\mathbf{A}) \leq 2$.
(D) $\mathbf{x} = [1,3,1]^T$ is a solution of the linear system.
(E) The vectors $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are linearly dependent.

9. Consider the linear system $\mathbf{Ax} = \mathbf{b}$, where $\mathbf{A} = [\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3] \in \mathbb{R}^{3\times3}$, $\mathbf{a}_1, \mathbf{a}_2, \mathbf{a}_3$ are column vectors of $\mathbf{A}$, and $\mathbf{b}$ is a non-zero vector. Suppose
$$\mathbf{a}_1 - \mathbf{a}_2 + 3\mathbf{a}_3 = \mathbf{0},\ \mathbf{a}_1 + 2\mathbf{a}_2 - \mathbf{a}_3 = \mathbf{b},\ \text{rank}(\mathbf{A}) = 2.$$
Which of the following are solutions of the linear system?
(A) $\mathbf{x} = [-1,4,-7]^T$
(B) $\mathbf{x} = [3,0,5]^T$
(C) $\mathbf{x} = [2,4,-2]^T$
(D) $\mathbf{x} = [3,1,3]^T$
(E) $\mathbf{x} = [-2,2,-6]^T$

10. Two matrices are row equivalent if one can be changed to the other by a sequence of elementary row operations. Which of the following statements are true?
    (A) If there exists a matrix $\mathbf{R}$ such that $\mathbf{B} = \mathbf{RA}$, then $\mathbf{A}$ and $\mathbf{B}$ are row equivalent.
    (B) If two matrices are row equivalent, then they have the same null space.
    (C) If two matrices are row equivalent, then they have the same eigenvalues.
    (D) If $\mathbf{E}$ is the reduced row echelon form of $\mathbf{A}$, then $\mathbf{E}$ and $\mathbf{A}$ are row equivalent.
    (E) Let $\mathbf{A} \in \mathbb{R}^{m\times n}$, $\mathbf{C} \in \mathbb{R}^{m\times n}$, and $\mathbf{b} \in \mathbb{R}^{m}$ be given. If $\mathbf{A}$ and $\mathbf{C}$ are row equivalent, then the two linear systems $\mathbf{Ax} = \mathbf{b}$ and $\mathbf{Cx} = \mathbf{b}$ have the same solution set.

11. Consider the linear system $\mathbf{Ax} = \mathbf{b}$. Let $\mathbf{A} = \mathbf{QR}$, where $\mathbf{Q}$ is an orthogonal matrix, and $\mathbf{R}$ is an upper triangular matrix. Suppose
$$\mathbf{R} = \begin{bmatrix} -1 & 4 & 2 \\ 0 & -2 & 1 \\ 0 & 0 & 3 \end{bmatrix},\ \mathbf{Q}^T\mathbf{b} = \begin{bmatrix} -3 \\ 7 \\ 15 \end{bmatrix}, \mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}.$$
    Which of the following statements are true?
    (A) $x_1 = 9$ (B) $x_2 = 1$ (C) $x_3 = 5$ (D) $x_1 + x_2 + x_3 = 12$ (E) $x_1 + x_2 + x_3 = 14$

12. Let $\hat{\mathbf{x}}$ be a least-squares solution of the linear system $\mathbf{Ax} = \mathbf{b}$. Which of the following statements are true?
    (A) $\hat{\mathbf{x}}$ satisfies $\mathbf{A}\hat{\mathbf{x}} = \mathbf{b}$.
    (B) $\hat{\mathbf{x}}$ satisfies $\mathbf{A}^T\mathbf{A}\hat{\mathbf{x}} = \mathbf{A}^T\mathbf{b}$.
    (C) $\hat{\mathbf{x}}$ always exists.
    (D) $\hat{\mathbf{x}}$ is unique.
    (E) $\mathbf{b} - \mathbf{A}\hat{\mathbf{x}}$ is orthogonal to any vector in the range space of $\mathbf{A}$.

13. Let $\mathbf{x}_1$ and $\mathbf{x}_2$ be eigenvectors of $\mathbf{A}$, and λ_1 and λ_2 be the corresponding eigenvalues. Suppose
$$\mathbf{x}_1 = \begin{bmatrix} -1 \\ 2 \end{bmatrix},\ \mathbf{x}_2 = \begin{bmatrix} 3 \\ 1 \end{bmatrix},\ \lambda_1 = 2,\ \lambda_2 = -1,\ \mathbf{y} = \begin{bmatrix} 1 \\ 5 \end{bmatrix},\ \mathbf{A}^{10}\mathbf{y} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix}.$$
    Which of the following statements are true?
    (A) $s_1 = -2045$
    (B) $s_1 = -2046$
    (C) $s_2 = 4096$
    (D) $s_2 = 4098$
    (E) $s_1 + s_2 = 2052$

以下第14題到第16題需要詳明推導計算過程。如推導計算過程錯誤，將酌扣分數或不給分。第15-16題中，$j = \sqrt{-1}$。

14. (10%) Use the Laplace transform to solve the following initial value problem.
$$y'' + 6y' + 9y = e^{-3t}\cos t,\quad y(0) = 0,\quad y'(0) = 0$$

15. (10%) The Fourier transform of a continuous-time real function is given as
$$Y(j\omega) = \int_{-\infty}^{+\infty} y(t)e^{-j\omega t}\,dt.$$

(a) Obtain the Fourier transform of the following function. (5%)

$$y(t) = \left(\frac{\sin 100\pi t}{\pi t}\right)^2$$

(b) To sample $y(t)$ with equal interval, what is the maximal sampling period T to possibly prevent from aliasing? (5%)

16. (15%) Let C be the circle $|z^* + j| = 2$ oriented in a positive sense where z^* indicates the complex conjugate of z, and a complex integral is defined as

$$g(z_0) = \int_C \frac{z^2 - z_0}{z^2 + z_0} dz$$

(a) Illustrate the contour C on a complex plane. Find $g(4)$. (10%)
(b) Find $g(10)$. (5%)

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國立中山大學112學年度碩士班暨碩士在職專班招生考試試題

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※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　

1. (10%) Consider a message signal $m(t)$ containing frequency components respectively at 100, 200, and 400 Hz. This signal is applied to an SSB modulator together with a carrier at 100 kHz, with only the upper sideband retained. In the coherent detector used to recover $m(t)$, the local oscillator supplies a sine wave of frequency 100.02 kHz.
   (A) Determine the frequency components of the detector output. (5%)
   (B) Repeat your analysis by assuming that only the lower sideband is transmitted. (5%)

2. (15%) For each of the following systems, determine whether the system is (1) linear, (2) time invariant, and (3) causal. Please write the answers in detail.
   (A) $y(t) = \cos(3t)x(t)$ (5%)
   (B) $y(t) = \int_{-\infty}^{2t} x(\tau)d\tau$ (5%)
   (C) $y(t) = \begin{cases} 0, x(t) < 0 \\ x(t) + x(t+2), x(t) \geq 0 \end{cases}$ (5%)

3. (15%) Consider the low-pass equivalent representation of a signal

$$u(t) = \sum_{n=-\infty}^{\infty} I_n g(t - nT)$$

   where

$$g(t) = \begin{cases} A, & 0 \leq t \leq T \\ 0, & \text{otherwise} \end{cases}$$

$$I_n = a_n - \frac{1}{\sqrt{3}} a_{n-1}$$

   and $\{a_n\}$ is a sequence of uncorrelated QPSK symbols that occur with equal probability and $E[|a_n|^2] = 1$.
   (A) Determine the autocorrelation function of $\{I_n\}$ (10%)
   (B) Determine the power spectral density of $u(t)$ (5%)

4. (15%) A bit error rate of $P_b = 10^{-3}$ is required for a system with a data rate of 100 Kbps to be transmitted over an AWGN channel using coherently detected MPSK modulation. The system bandwidth is 50kHz. Assume that the system frequency transfer function is a raised cosine with a roll-off characteristic of $r = 0.5$ and a Gray code is used for the symbol to bit assignment. What E_b/N_0 is required for the specified P_B? (Hint: $Q(1.5 \times 10^{-3}) = 2.96$)

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5. (25%) Three messages are transmitted equiprobably over an AWGN channel with noise PSD = $N_0/2$:

$$s_1(t) = \begin{cases} 2, & 0 \le t \le T/2, \\ -2, & T/2 < t \le T, \\ 0, & \text{otherwise.} \end{cases}$$

$$s_2(t) = \begin{cases} \sqrt{2}+1, & 0 \le t \le T/2, \\ \sqrt{2}-1, & T/2 < t \le T, \\ 0, & \text{otherwise.} \end{cases}$$

$$s_3(t) = \begin{cases} -\sqrt{2}+1, & 0 \le t \le T/2, \\ -\sqrt{2}-1, & T/2 < t \le T, \\ 0, & \text{otherwise.} \end{cases}$$

(A) Use the Gram-Schmidt orthogonalization procedure to find an orthonormal basis for this set of signals. (10%)

(B) Draw the signal constellation of the ternary messages. (5%)

(C) Sketch the optimal decision regions R_1, R_2, and R_3. (Please label the decision boundaries clearly) (5%)

(D) Design the receiver. (5%)

6. (20%) For a binary transmission system, $s_i(t)$, $i = 0$ or 1, is the transmitted signal, $n(t)$ is the additive noise, $r(t)$ is the received signal and $r(t) = s_i(t) + n(t)$ for each symbol duration T. The output of the correlator receiver is $z(T) = a_i + n_o$. The signal component a_i is $a_0 = -1$ or $a_1 = 1$, and the noise component n_o has a probability density function of $p(n_0) = \left(\frac{1}{2}\right)\Lambda\left(\frac{n_0}{2}\right)$.

(A) If $s_1(t)$ and $s_2(t)$ are transmitted with an equal probability, determine the value of the optimum decision threshold and the bit error probability. (10%)

(B) If $s_1(t)$ are transmitted with a probability of 0.8, determine the value of the optimum decision threshold and the bit error probability. (10%)

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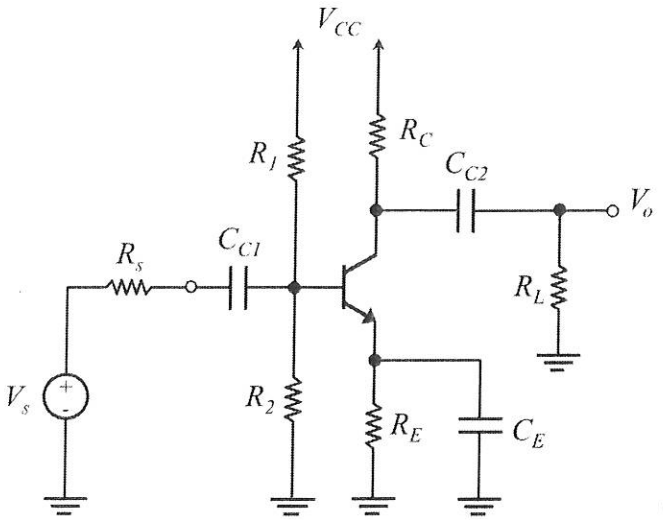
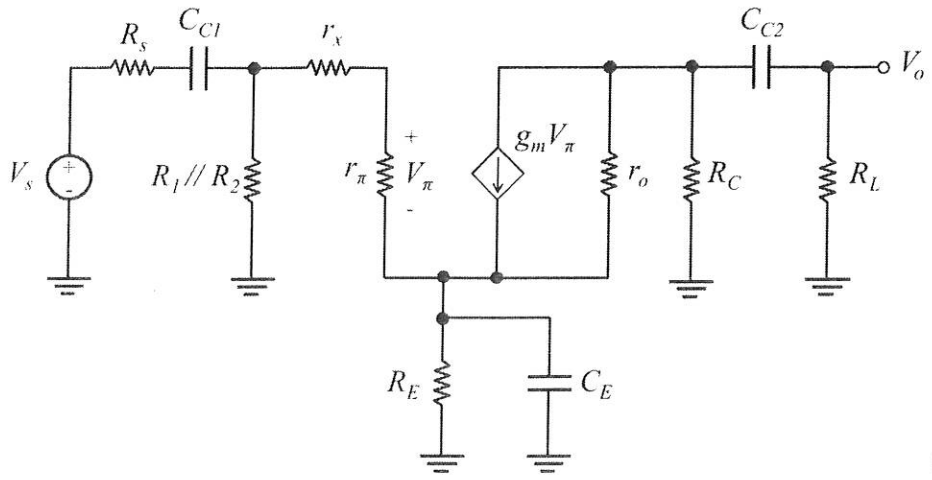
※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　

1. (15%) A fourth-order filter has zero transmission at ω = 0, ω = 2 rad/s, and at ω = ∞. The natural modes are $-0.1 \pm j0.5$ and $-0.1 \pm j1.5$. Find the transfer function $T(s)$. (*Hint:* The natural modes are the time functions corresponding to the poles.) (15%)

2. (35%) Consider the common-emitter amplifier of Fig. 1 under the following conditions: R_s = 5 kΩ, R_1 = 33 kΩ, R_2 = 22 kΩ, R_E = 3.9 kΩ, R_C = 4.7 kΩ, R_L = 5.6 kΩ, V_{CC} = 5 V. The dc emitter current can be shown to be $I_E \approx 0.33$ mA, at which β_0 = 120, r_o = 300 kΩ, and r_x = 50 Ω.
   (a) Find the input resistance, R_{in}. *(Hint:* $R_{in} = R_1 \,//\, R_2 \,//\, (r_x + r_\pi)$*)* (10%)
   (b) Find the midband gain, A_M. (10%)
   (c) For $C_{C1} = C_{C2}$ = 1 μF and C_E = 10 μF, estimate the low-frequency 3-dB frequency. Also find the frequency of the zero introduced by C_E. (15%)



(a)



(b)

Figure 1. (a) common-emitter amplifier stage; (b) Equivalent circuit for the amplifier of Fig. 1(a) in the low-frequency band.

3. (20%) Design the circuit of Fig. 2 so that the transistor operates at I_D = 0.4 mA and V_D = +1 V. The NMOS transistor has V_t = 2 V, $\mu_n C_{ox}$ = 20 μA/V^2, L = 10 μm, and W = 400 μm. Neglect the channel-length modulation effect (i.e., assume that λ= 0).
   (a) Find R_S. (10%)
   (b) Find R_D. (10%)

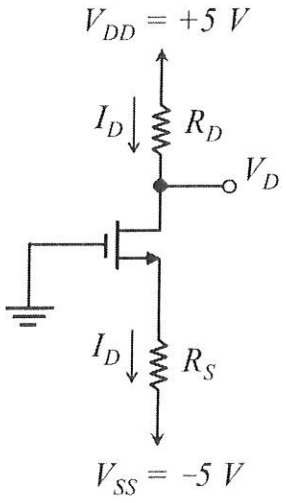


Figure 2.

4. (30%) For the circuit shown in Fig. 3, find the values of the labeled node voltages for :
   (a) β = ∞. (15%)
   (b) β = 100. (15%)

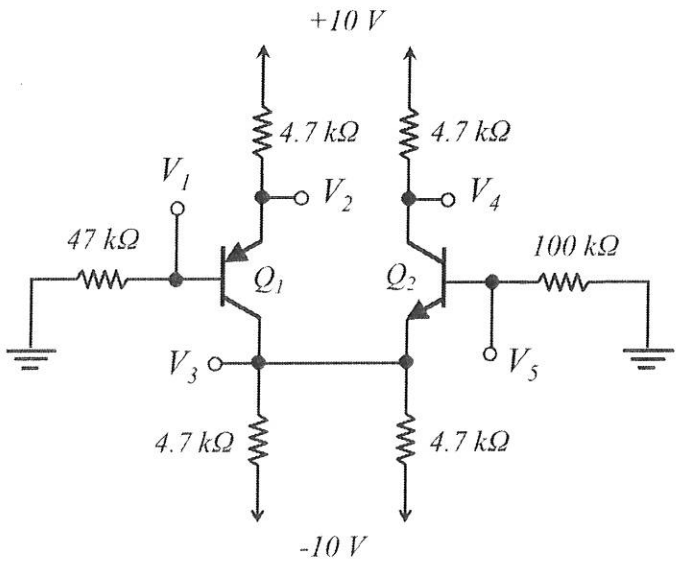


Figure 3.

國立中山大學112學年度
碩士班暨碩士在職專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、通訊所碩士班乙組、電波聯合碩士班】

－作答注意事項－

考試時間：100分鐘

- **考試開始鈴響前不得翻閱試題，並不得書寫、劃記、作答。**請先檢查答案卷（卡）之應考證號碼、桌角號碼、應試科目是否正確，如有不同立即請監試人員處理。
- **答案卷限用藍、黑色筆(含鉛筆)書寫、繪圖或標示**，可攜帶橡皮擦、無色透明無文字墊板、尺規、修正液（帶）、手錶(未附計算器者)。每人每節限使用一份答案卷，請衡酌作答(不得另攜帶紙張，亦不得使用應考證空白處作為計算紙使用)。
- 答案卡請以2B鉛筆劃記，不可使用修正液（帶）塗改，未使用2B鉛筆、劃記太輕或污損致光學閱讀機無法辨識答案者，後果由考生自負。
- 答案卷（卡）應保持清潔完整，不得折疊、破壞或塗改應考證號碼及條碼，亦不得書寫考生姓名、應考證號碼或與答案無關之任何文字或符號。
- 可否使用計算機請依試題資訊內標註為準，如「可以」使用，廠牌、功能不拘，唯不得攜帶具有通訊、記憶或收發等功能或其他有礙試場安寧、考試公平之各類器材、物品（如鬧鈴、行動電話、電子字典等）入場。
- **試題及答案卷（卡）請務必繳回，未繳回者該科成績以零分計算。**
- **試題採雙面列印，考生應注意試題頁數確實作答。**
- **違規者依本校招生考試試場規則及違規處理辦法處理。**

國立中山大學112學年度碩士班暨碩士在職專班招生考試試題

科目名稱：電磁學【電機系碩士班戊組、通訊所碩士班乙組、電波聯合碩士班】題號：482004

※本科目依簡章規定「可以」使用計算機（廠牌、功能不拘）（問答申論題）　

1. (25%) The length of a coaxial cable with outer and inner conductors is L. The space between the outer conductor of inner radius a and the inner conductor of radius b is filled by a medium with permittivity ϵ and conductivity σ. The leakage resistance between these two conductors is R and the capacitance of this cable is C. Determine RC.

2. (25%) The rectangular and circular loops are coplanar as shown in Fig. 1. The radius of the circular loop is c. Determine the mutual inductance between these two loops. Assume that b >> c and c >d.

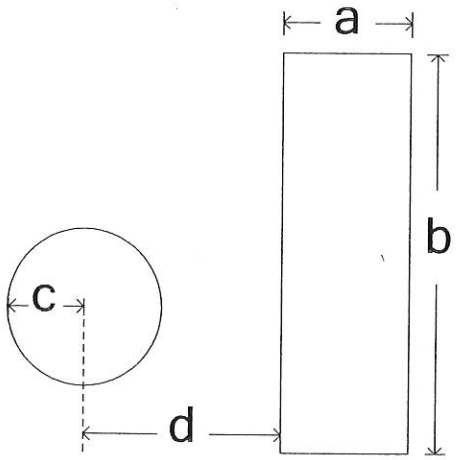


Fig. 1

3. (5%) (a) Write Maxwell's equations in differential form.
   (5%) (b) Write the EM boundary conditions.
   (5%) (c) Explain homogeneous Helmholtz's equation.
   (5%) (d) Explain dispersion.

4. As shown in Fig. 2, a uniform plane wave ($\mathbf{E}_i$, $\mathbf{H}_i$) of an angular frequency ω is incident from air on a very large, perfectly conducting wall at an angle of incidence θ_i with perpendicular polarization. Find
   (5%) (a) the current induced on the wall surface, and
   (5%) (b) the time-average Poynting vector in medium 1.

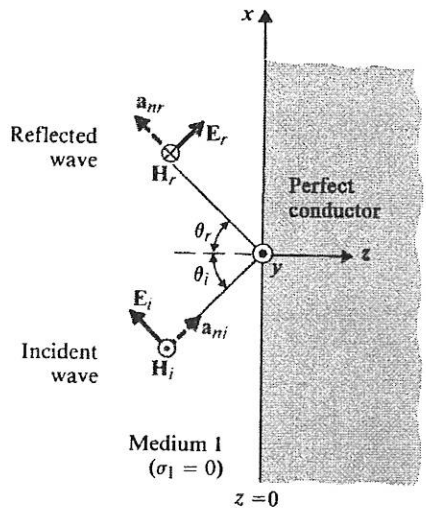


Fig. 2

5. (10%) As shown in Fig. 3, for a coaxial line in TEM mode, find **E** and **H**.

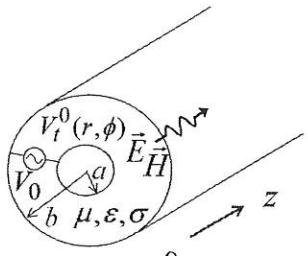


Fig. 3

6. The open-circuit and short-circuit impedance at the input terminals of a lossless transmission line of length 1.5 (m), which is less than a quarter wavelength, are $-j54.6$ (Ω) and $j103$ (Ω), respectively.
(4%) Find Z_0 and γ of the line.
(4%) Without changing the operating frequency, find the input impedance of a short-circuited line that is twice the given length.
(2%) How long should the short-circuited line be in order for it to appear as an open circuit at the input terminals?