國立成功大學

114學年度碩士班招生考試試題

編　號：136

系　所：電腦與通信工程研究所

科　目：電磁學及電磁波

日　期：0210

節　次：第 2 節

注　意：1.可使用計算機
2.請於答案卷(卡)作答，於試題上作答，不予計分。

For your reference: $\varepsilon_0 = 10^{-9}/36\pi\ (F/m)$ $\mu_0 = 4\pi\times10^{-7}\ (H/m)$ $\eta_0 = 120\pi\ (\Omega)$

Permitivity $\varepsilon = \varepsilon_r\varepsilon_0$ *Permeability* $\mu = \mu_r\mu_0$ *Conductivity* σ

1. Brief answers.

(a) A parallel-plate capacitor, biased with a voltage source of V, is composed of three kinds of different materials as depicted in **Fig. A**. The thickness of material #1 and material #2 are d_1 and d_2, respectively. The related vectors of the electric field intensity $\vec{E_i}$ and flux density $\vec{D_i}$ are also depicted in the figure. Please express the equation for calculating the voltage V with respect to the electric fields all. (3%)

(b) As mentioned in (a) above, according to the boundary conditions, what are the relationships among the flux density vectors all? (3%)

(c) According to the Maxwell equations, will a current flux density $\vec{J}$ generate the magnetic field instensity $\vec{H}$ or magnetic flux density $\vec{B}$? (3%)

(d) What does the Poynting theorem of an electromagnetic wave mean? (6%)

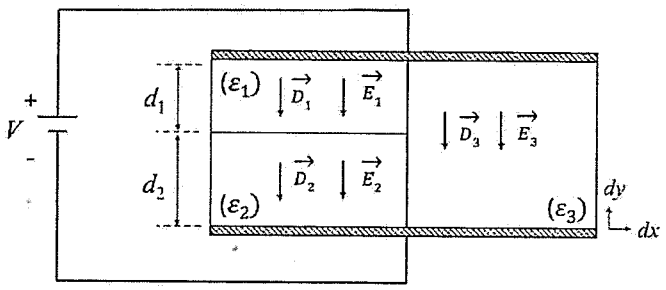

Fig. A

2. A parallel-plate capacitor with an area of S, spacing with a distance of d, is considered and as shown in **Fig. B**. If a dielectric slad, whose dielectric constant is ε_r and thickness is t, is placed between the two metal plates of the capacitor. After charging the capacitor system to the voltage V and then open the switch.

(a) Please calculate the work needed to plug out the dielectric slab. (5%)

(b) Re-calculate the work needed if we replace the dielectric slab with a metal one. (5%)

(c) Please discuss which value of ε_r will make the works done in (a) and (b) equal to each other. (5%)

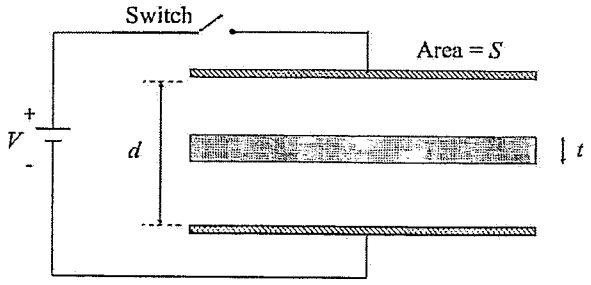

Fig. B

3. A metal wire loop , carrying a current magnitude of I, is configured with the shape shown in **Fig. C**. The radian angle between the ends of the straight line is 2θ. Please find the magnetude of the magnetic flux density $\vec{B}$ at the center point. [hint: $\int cos(x)dx = sin(x)$] (10%)

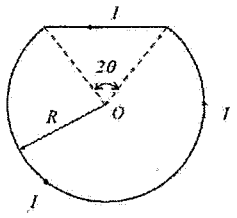

Fig. C

4. (a) When considering an electromagnetic (EM) wave propagating in free space, the angular frequency ω and the phase constant β have a special relationship. If $\omega = 2\pi\times10^8$ (rad/s), please find β. (5%)
(b) Given the electric field of an EM wave expressed as $\vec{E}(z;t) = Re\left[\left(\widehat{a_x}\cdot 1\cdot e^{-j\beta z} + \widehat{a_y}\cdot(j\sqrt{3})\cdot e^{-j\beta z}\right)\cdot e^{j\omega t}\right]$, show that this is an electric field which satisfies the wave equation. [hint: you can also do it with the help of Helmholtz equation $\nabla^2\vec{E}(z) + \beta^2\vec{E}(z) = 0.$] (5%)
(c) Is the mentioned electric field in (b) a linear, circular, or elliptical polarization field? Prove it. (5%)
(d) Find the time-average power density of the above-mentioned EM wave. (5%)

5. The lossless lump-parameter network shown in **Fig.D** is used to match a 50-Ω transmission line to the input of an RF transistor operating at 1 GHz. The input reflection coefficient for the transistor is $\Gamma = 0.6\cdot e^{-j150^\circ}$, measured for a 50-Ω system. Please find the values of the inductor (L) and capacitor (C), respectively. (10%)

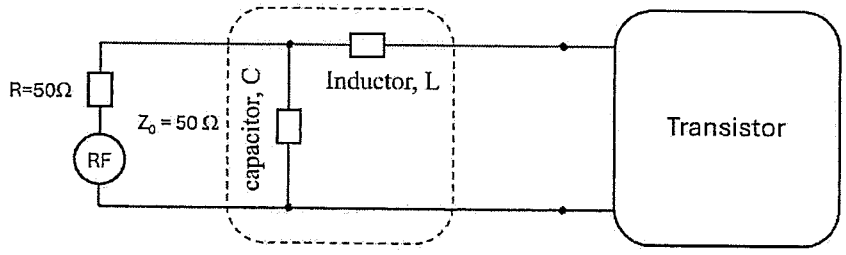

Fig. D

6. A lossless, air-filled cylindrical waveguide with inside diameter 2.95 cm is operated at 15 GHz. For the TM_{11} mode propagating in the +z direction, please find the cutoff frequency, guided wavelength, and wave impedance of this waveguide. [hint: referred to **Table A** for the roots X_{np} of Bessel function $J_n(X)=0$.] (15%)

Table A Roots x_{np} of $J_n(x)=0$

	n = 0	n = 1	n = 2
p = 1	2.405	3.832	5.136
p = 2	5.520	7.016	8.417

7. (a) An antenna, which radiates 2 MW of power, has a directivity of 20 dB. Find the power density radiated in the direction of the main beam, 10 km from the source. (10%)

   (b) Following the case in (a), if the receiver's antenna has a directivity of 10 dB. The operation frequency is 100 MHz. What is the possible maximum received power available at the receiving end? (5%)