國立成功大學

113學年度碩士班招生考試試題

編　號：181

系　所：電腦與通信工程研究所

科　目：電磁學及電磁波

日　期：0201

節　次：第 2 節

備　註：可使用計算機

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※ 考生請注意：本試題可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，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. Given a vector field $\vec{F} = \hat{a}_x\cdot(4y\text{-}C_1z)+\hat{a}_y\cdot(C_2x\text{-}z)-\hat{a}_z\cdot(C_3y+z)$ in the Cartesian coordinate, where C_1, C_2 and C_3 are the constants.

(a) Determine the constants C_1, C_2 and C_3 if $\vec{F}$ is irrotational. [5%]

(b) Find the Laplacian of the field, $\nabla^2\vec{F}$. [5%]

2. A point charge +Q is at a distance d from the center of a spherical metal shell of radius r, where the shell is floating and r < d as shown in **Fig. A**

(a) Please find the magnitudes of image charges and the related locations by the method of image. [5%]

(b) Find the net interaction force between this charge and the shell. Also identify this is an attractive force or repulsive force? [5%]

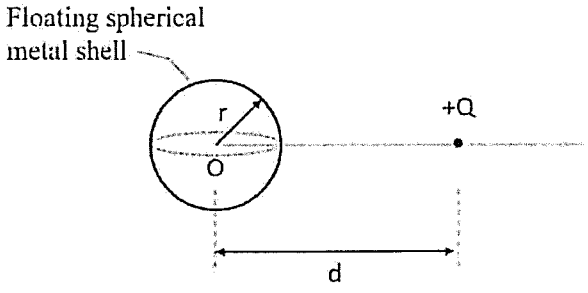

Fig. A

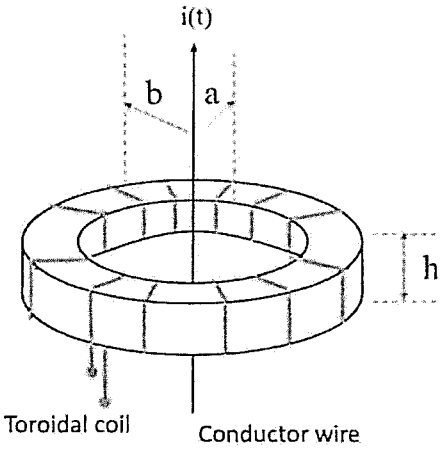

Fig. B

3. A toroidal coil of 3600 turns is wound over a magnetic ring with inner radius of a (=12 mm), outer radius of b (=15 mm), height of h (=10 mm), and relative permeability of 1200. A very long, straight conductor passing through the center of the toroid carries a time-varying current i(t), as shown in **Fig. B**. Determine the mutual inductance between the toroid coil and the straight conductor. [15%]

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4. A magnetic circuit with its pertinent dimensions is depicted in **Fig. C (left,** but not in scale). Each section length is listed in **Table I**. The magnetization characteristic of the magnetic material is shown **Fig. C (right)**. If the magnetic circuit has a uniform thickness of 20 mm and the flux density in the air gap is 1.0 Tesla. The number of turns in the coil is 600 turns. (note: 1 Tesla = 1 Wb/m^2 = 10^4 Gauss, mmf = magnetic motive force)

(a) The following table lists the results calculated by an engineer. But unfortunately, some of listed values are lost. Please re-fill up the table according to your calculation and show the complete table in your answer sheet. [10%]

(b) Please find the current in the 600-turn coil. [5%]

Table I. Calculation results for the magnetic circuit

Section	Flux (mWb)	Cross-section Area (mm^2)	B (Tesla)	H (Ampere-turn/m)	Length (mm)	mmf (Ampere-turn)
a-b	0.12	120	1.0	795,774.72	2	1591.55
b-c	0.12	120	1.0	1590.0	56	89.04
c-d	0.12	160	0.75	1065.0	87	(6)
d-e	0.12	400	(4)	(5)	134	(7)
e-f	0.12	(2)	0.75	1065.0	87	(8)
f-a	(1)	(3)	1.0	1590.0	76	(9)
				Total mmf drop in the magnetic circuit:		(10)

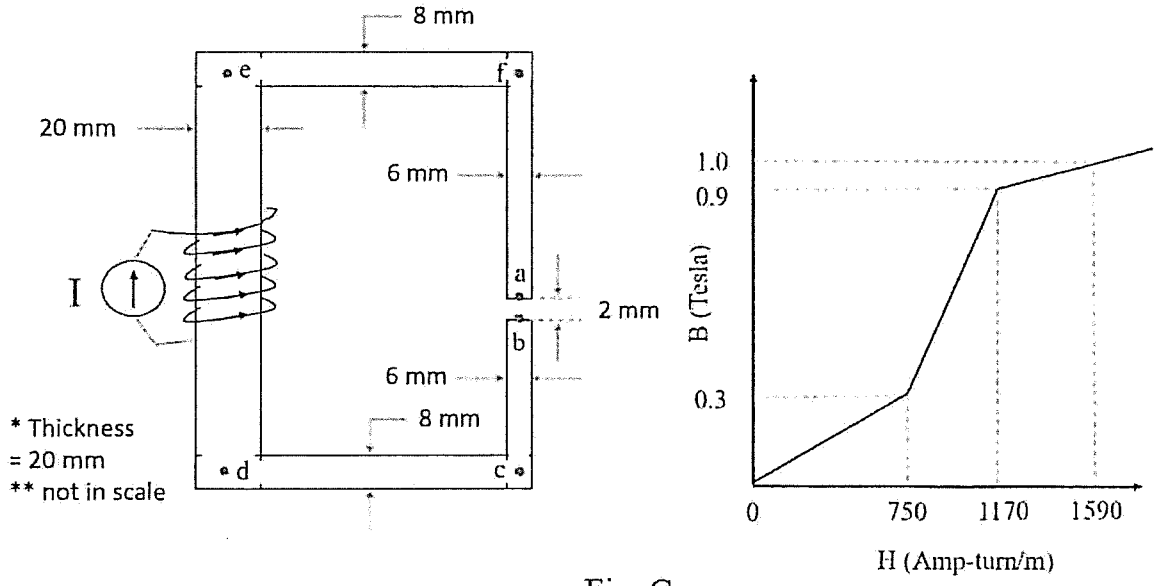

Fig. C

5. If the electric field intensity as given by $\bar{E} = \hat{a}_x \cdot 377\cos(10^9 t - 10z)$ V/m represents a uniform plane wave propagating in the z direction in a dielectric medium ($\mu = \mu_0$, $\varepsilon = \varepsilon_r\varepsilon_0$), please determine

(a) the dielectric constant ε_r, [3%]

(b) the velocity of propagation, [3%]

(c) the intrinsic impedance, [3%]

(d) the magnetic field intensity, and [3%]

(e) the average power density in the medium. [3%]

6. A 100-m-long lossless transmission line has a total inductance and capacitance of 35 μH and 22 nF, respectively. The input voltage signal operates at 100 kHz. At the end of this transmission line is terminated with a resistive load R_L = 50 Ω. Determine

(a) the phase constant of voltage-wave on this transmission line, [3%]

(b) the characteristic impedance of the transmission line, [3%]

(c) the reflection coefficient at the end of the load, and [3%]

(d) the voltage standing wave ratio VSWR. [3%]

(e) At the load end, is the voltage of the standing wave minimum or maximum? Why? [3%]

7. An air-filled rectangular waveguide has the dimensions of a = 5.08 cm and b = 2.54 cm.

(a) Find the dominant mode (i.e., expressed in TE_{mn} or TM_{mn}, $m,n \in \{0\} \cup N$) and its lowest cutoff frequency. [5%]

(b) If excite the waveguide at a frequency of 15 GHz, please calculate the cutoff frequency and the wave impedance of TM_{21} mode. [5%]

8. (a) What is the directive gain of an antenna? And, what is the power gain of an antenna? Please also discuss their difference as much as you know. [5%]

(b) A half-wave dipole antenna radiates 15 kW at a frequency of 450 MHz. Another half-wave dipole antenna situated at a distance of 30 km is used as a receiving antenna. The directive gains of the transmitting antenna and the receiving antenna are 2.15 dB and 1.76 dB, respectively. If both antennas are symmetrically placed in the x-y plane, as shown in **Fig. D**, and the medium is free space, determine the effective area of each antenna and the power received by the receiving antenna. [5%]

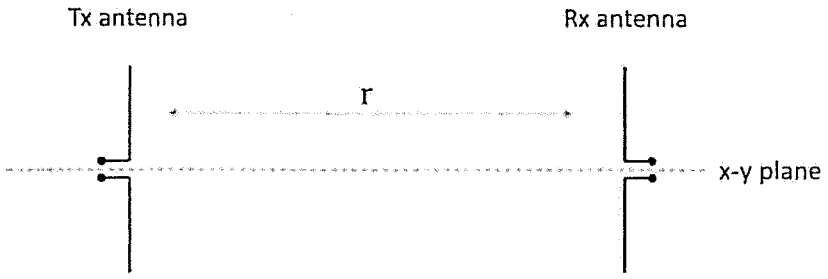

Fig. D