國立成功大學 109 學年度碩士班招生考試試題

系　　所：電腦與通信工程研究所

考試科目：電磁學及電磁波

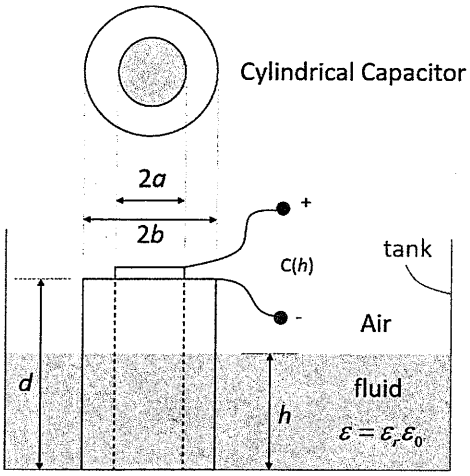
考試日期：0211，節次：2

※ 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); $\eta_0 = 120\pi$ (Ω)

Permittivity ε ($=\varepsilon_r\varepsilon_0$); Permeability μ ($=\mu_r\mu_0$); Conductivity σ

1. A simple capacitive fuel gauge can be built by a cylindrical capacitor, as shown in **Fig. A**. The diameter of the inner copper cylinder is $2a$ and the diameter of the outer copper cylinder shell is $2b$. If d is the cylinder's length and the relative permittivity of the fluid is ε_r. Find the general relation between the fluid level h and the capacitance C (i.e., the function C(h)). [15%]



Capacitive Fuel Gauge

Fig. A

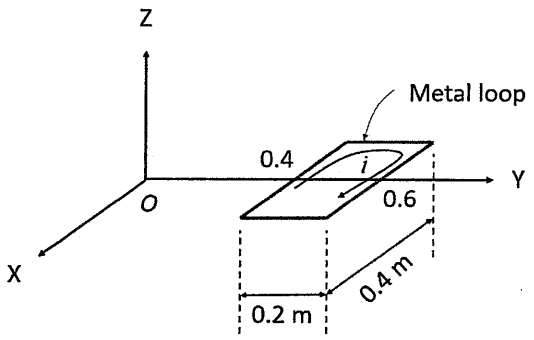


Fig. B

2. (a) The rectangular metal loop (with an internal series resistance of 10 Ω) shown in **Fig. B** moves toward the original at a velocity of $\vec{v} = -100\,\hat{a}_y$ (m/sec) in a magnetic flux field $\vec{B} = 0.5\,e^{-0.5y}\,\hat{a}_z$ (T). Find the current at the instant when the coil sides are at y = 0.4 m and 0.6 m. [10%]

(b) If the above-mentioned metal loop moves with a velocity of $\vec{v} = +20\,\hat{a}_x$ along the x-direction, find the current magnitude. [5%]

3. Given the following electric field and magnetic field that satisfy the source-free Maxwell's equations in free space,

$\vec{E}(z)=20\pi\, e^{j(10^8\, t-\beta z)}\,\hat{a}_x$ (V/m); $\vec{H}(z)=H_0\, e^{j(\omega t-\beta z)}\,\hat{a}_y$ (A/m)

(a) Please show out the equation set of source-free Maxwell's equations in $\vec{E}$ and $\vec{H}$ notations. [5%]

(b) Please find the wave propagation direction, ω, H_0, and β ($\beta>0$). [5%]

(c) Find the time-average propagation power density (W/m^2). [5%]

4. The magnetic circuit shown in **Fig. C** is cast-iron with a mean length $\ell_c = 0.5$ (m) and square cross-section area of 4×10^{-4} (m^2). The air-gap length is $\ell_a = 0.002$ (m) and the coil contains 400 turns. Find the current I required to establish an air-gap flux of 80×10^{-6} (Wb). Assume there is no fringing effect. The B-H curve of cast-iron is also given in **Fig. C**. [15%]

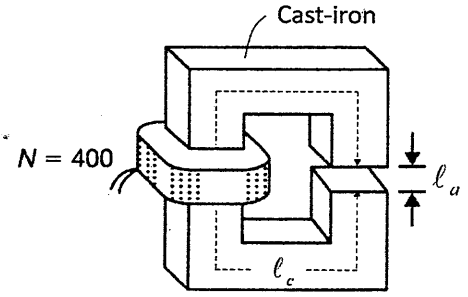
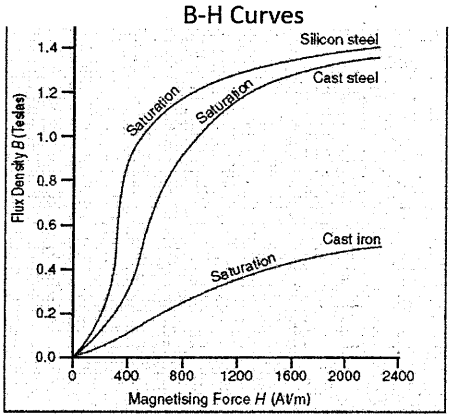


Fig. C



5. A lossless, air-filled cylindrical waveguide, which inside diameter is 3 cm, is operated at 14 GHz and placed along the z-axis. The solution of the electric field at a cross section in TM_{np} mode can be given by

$$E_{z,np}(r,\phi) = E_{np} J_n(k_{c,np} r)\cos(n\phi) \quad \text{where n} \in \{0,1,2,\ldots\} \text{ and p} \in \{1,2,3,\ldots\}$$

The roots of Bessel function $J_n(x)$ are given in the following table. For the TM_{21} mode propagating in the +z direction, find the cutoff frequency, guided wavelength, and wave impedance. [15%]

Zeros of $J_n(x)$, x_{np}

	n = 0	**n = 1**	**n = 2**
p = 1	2.405	3.832	5.136
p = 2	5.520	7.016	8.417
p = 3	8.645	10.173	11.620

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6. (a) A plane wave incident on a plane dielectric boundary is illustrated in **Fig. D**. Please identify which case it belongs to. Perpendicular polarization or parallel polarization? Please also give your reason why. [2%]

(b) Given the incident electric and magnetic field intensity phasors in medium #1 as

$$\vec{E}_i(x,z)=\hat{a}_y\, E_{io} e^{-j\beta_1(x\sin\theta_i+z\cos\theta_i)} \quad \text{and} \quad \vec{H}_i(x,z)=\left(-\hat{a}_x \frac{E_{io}}{\eta_1}\cos\theta_i+\hat{a}_z \frac{E_{io}}{\eta_1}\sin\theta_i\right) e^{-j\beta_1(x\sin\theta_i+z\cos\theta_i)},$$

respectively. Please show out the reflected electric and magnetic field phasors in medium #1 and the transmitted electric and magnetic field phasors in medium #2. [8%]

(c) According to the boundary conditions of electromagnetic fields, please prove that the transmission coefficient τ is equal to $\dfrac{2\eta_2\cos\theta_i}{\eta_2\cos\theta_i+\eta_1\cos\theta_t}$. [5%]

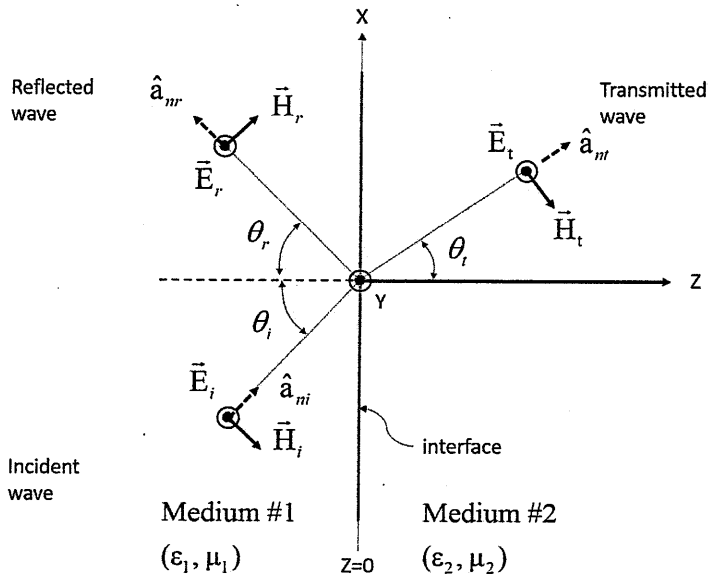

Fig. D

7. (a) There is an ideal directional antenna which radiates a total time-averaged power 1W in a solid angle of 0.2π uniformly. What is its directive gain? Note: You have to state your reason or you have to show your steps of calculation. [5%]

(b) A half-wavelength dipole antenna (whose directivity D = 1.64) is used to transmit at 80 MHz and 100 W. A receiving antenna in the form of a Hertzian dipole (whose directivity D = 1.5) is used to receive the wave power from the transmission antenna 20 km away. Please find the maximum power received by the receiving antenna. [5%]