國立成功大學

110學年度碩士班招生考試試題

編　號：167

系　所：電機工程學系

科　目：電磁學

日　期：0202

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。

$\varepsilon_0 = \dfrac{10^{-9}}{36\pi}$ F/m

In spherical coordinates: $\nabla \cdot \vec{A} = \dfrac{1}{r^2}\dfrac{\partial}{\partial r}\left(r^2 A_r\right) + \dfrac{1}{r\sin\theta}\dfrac{\partial}{\partial \theta}\left(A_\theta \sin\theta\right) + \dfrac{1}{r\sin\theta}\dfrac{\partial A_\phi}{\partial \phi}$

$\cos\alpha\cos\beta = \dfrac{1}{2}\left[\cos(\alpha-\beta)+\cos(\alpha+\beta)\right]$, $\int_0^{2\pi} \sin^2 x dx = \pi$

每題 10 分

1. A spherical shell has a and b as inner and outer radii, respectively. If polarization vector $\vec{P} = 4r\hat{a}_r$ C/m^2 in spherical coordinate system, determine (a) the total bound charge on the inner surface, (b) the total bound charge on the outer surface, (c) the total bound volume charge, (d) the electric field everywhere.

2. A spherical capacitor has inner radius a and outer radius b and is filled with an inhomogeneous dielectric with $\varepsilon = \varepsilon_0 k / r^2$. Find the capacitance of the capacitor.

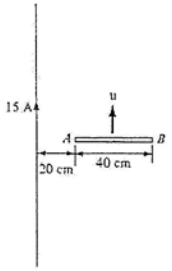
3. A point charge of 10 μC is located at (1, 1, 1) in a rectangular coordinate system, and the positive portions of the coordinate planes occupied by three mutually perpendicular plane conductors maintained at zero potential. Find the force on the charge due to the conductors.

4. For a magnetic vector potential in free space,

$$\vec{A} = \left(2x^2 y + yz\right)\hat{a}_x + \left(xy^2 - xz^3\right)\hat{a}_y - \left(6xyz - 2x^2 y^2\right)\hat{a}_z \text{ Wb/m}$$

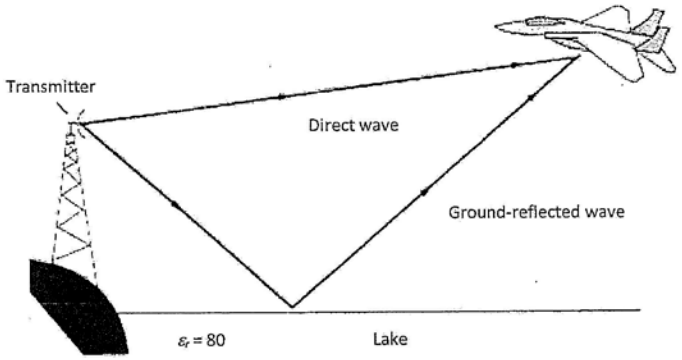
Find the magnetic flux through a loop described by $x = 1, 0 < y < 2, 0 < z < 2$.

5. A conducting rod moves with a constant velocity of $3\hat{a}_z$ m/s parallel to a long straight wire carrying a current of 15 A as in the figure. Calculate the emf induced in the rod and state which end is at the higher potential.



6. The magnetic field phasor of an electromagnetic wave in air is given by $\vec{H}(y)=\hat{a}_z 1.83\times10^{-4}e^{-j4y}\ \mathrm{A\cdot m^{-1}}$ (a) Find the angular frequency ω of the wave such that $\vec{H}$ satisfies all of Maxwell's equations. (b) Find the corresponding time-harmonic electric field $\vec{E}$. (c) Find the electric flux density $\vec{D}$ and the displacement-current density $\vec{J}_d$.

7. Consider a ground-to-air communication system as shown in the figure. The receiver antenna is on an aircraft over a huge lake circling at a horizontal distance of ~10 km from the transmitted antenna as it waits for a landing time. The transmitted antenna is located at the shore mounted on top of a 100-m tower above the lake surface overlooking the lake and transmitted a parallel-polarized (with respect to the plane of incident) signal. The pilot of the aircraft experiences noise (sometimes called *ghosting effect*) in his receiver due to the destructive interference between direct wave and the ground-reflected wave and needs to adjust his altitude to minimize this interference. Assuming the lake to be flat and lossless with $\varepsilon_r \simeq 80$, find the critical height of the aircraft for the pilot in order to achieve clear transmission between the transmitter and the receiver.

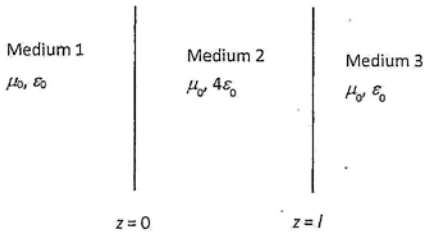


8. A parallel-plate waveguide with a plate separation of 2 cm is to be used to connect a 12-GHz microwave transmitter to an antenna. Find all the propagation modes if the waveguide is filled with polyethylene (assume it is lossless, with $\varepsilon_r \simeq 2.25, \mu_r = 1$).

9. For the system shown below, find the lowest values of l for which no reflection occurs for a uniform plane wave having the electric field

$$\vec{E} = E_0 \cos 4\pi \times 10^9 t \cos \pi \times 10^9 t \hat{a}_x$$

at $z = 0$ normally incident on the interface from medium 1.



10. At the far field, an antenna produces a time-average power as

$$\mathcal{P}_{ave} = \frac{2\sin\theta\cos\phi}{r^2} \text{ W/m}^2, \quad 0 < \theta < \pi, 0 < \phi < \pi/2$$

Calculate the directivity gain and the directivity of the antenna.