國立成功大學

111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：0219

節　次：第 2 節

備　註：可使用計算機

編號： 167

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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。

$$\mu_0 = 4\pi \times 10^{-7}\ \text{H/m},\quad \varepsilon_0 = \frac{10^{-9}}{36\pi}\ \text{F/m},\quad g = 9.8\ \text{m/s}^2$$

In cylindrical coordinate system:

$$\nabla \times \vec{A} = \left[\frac{1}{\rho}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right]\hat{a}_\rho + \left[\frac{\partial A_\rho}{\partial z} - \frac{\partial A_z}{\partial \rho}\right]\hat{a}_\phi + \frac{1}{\rho}\left[\frac{\partial (\rho A_\phi)}{\partial \rho} - \frac{\partial A_\rho}{\partial \phi}\right]\hat{a}_z$$

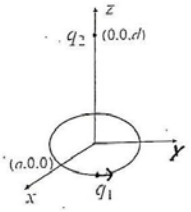
$$\nabla V = \frac{\partial V}{\partial \rho}\hat{a}_\rho + \frac{1}{\rho}\frac{\partial V}{\partial \phi}\hat{a}_\phi + \frac{\partial V}{\partial z}\hat{a}_z$$

In sphrical coordinate system:

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

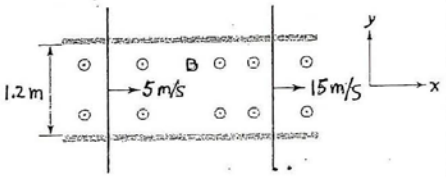
$$\nabla V = \frac{\partial V}{\partial r}\hat{a}_r + \frac{1}{r}\frac{\partial V}{\partial \theta}\hat{a}_\theta + \frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}\hat{a}_\phi$$

1. [10%] In a free space, there is a point charge q_1 circling on xy-plane about an origin with a constant angular velocity ω as shown in the figure. If q_1 happens to be at $(a,0,0)$ as $t=0$, find the electric force experienced at any time t by the point charge q_2 stationary at $(0,0,d)$.



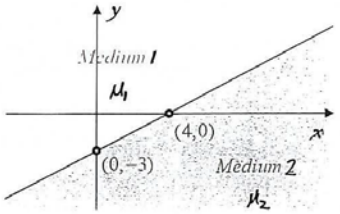
2. [10%] A conducting sphere of radius a has a total charge Q uniformly distributed on its surface. If the sphere is embedded in a medium with permittivity $\varepsilon = \varepsilon_0\left(1+\frac{a}{r}\right)^2$, find the energy stored.

3. [10%] Two straight bars are placed together initially and then slide over two stationary rails, as illustrated in the figure. Assume the bars are made of perfect conductor while the rails have a line resistivity of 0.2 Ω/m. If $\vec{B} = 0.2\sin(10t)\hat{a}_z\ \text{Wb/m}^2$, determine the electric current in the loop.



4. [10%] A 50 Ω lossless transmission line has load $Z_L = 60 + j40\ \Omega$. (a) Determine the shortest electrical length of the line if the input impedance is purely real. (b) Find standing wave ratio.

5. [10%] A current sheet of $10\hat{a}_z\ (\text{A/m})$ separates two regions as shown in the figure. Medium 2 has a magnetic field intensity of $9\hat{a}_x + 38\hat{a}_y + 4\hat{a}_z\ (\text{A/m})$ and a relative permeability of 200. If medium1 has a relative permeability of 1000, determine the magnetic field intensity in medium 1.

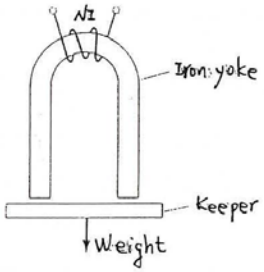


6. [10%] A coaxial cable consists of two conducting cylinders of radii a and b and a dielectric medium with permittivity of ε. The magnetic field in the cable is

$$\vec{H} = \frac{I_0}{2\pi\rho}\sin(\omega t - \beta z)\hat{a}_\phi \quad \text{for} \quad a < \rho < b$$

where I_0 is a constant. Find the time-average power flowing through the cable.

7. [10%] A U-shaped electromagnet shown in the figure is designed to lift a 400 kg mass (which includes the mass of the keeper). The iron yoke ($\mu_r = 3000$) has cross section of $S_{\text{iron}} = 40\ \text{cm}^2$ and mean length of $l_{\text{iron}} = 50\ \text{cm}$, and the air gaps are each $l_{\text{gap}} = 0.1\ \text{mm}$ long. Neglecting the reluctance of the keeper, calculate the number of turns in the coil when the excitation current is $I = 1\ \text{A}$.



8. [15%] A parallel-plate capacitor has its plates at $x = 0$, d and the space between the plates is filled with an inhomogeneous material with permittivity $\varepsilon = \varepsilon_0\left(1 + \frac{x}{d}\right)$. If the plate at $x = d$ is maintained at V_0 while the plate at $x = 0$ is grounded, find:

(a) potential V in the capacitor

(b) the capacitance, assuming that each plate had area S.

(c) the polarization charge density ρ_{Pv} at $x = \frac{d}{2}$.

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9. [15%] An electron beam forms a current of density

$$\vec{J} = \begin{cases} J_0\left(1-\dfrac{\rho^2}{a^2}\right)\hat{a}_z, & \rho < a \\ 0, & \rho > a \end{cases}$$

(a) Find the magnetic field intensity everywhere.

(b) Find the magnetic vector potential for $\rho > a$ if $\vec{A}(\rho = a) = 0$.