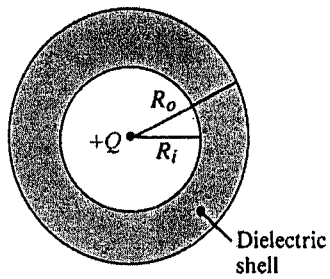
類組：電機類　科目：電磁學 A(3007)　※請在答案卷內作答

一、 A positive point charge Q is at the center of a spherical dielectric shell of an inner radius R_i and an outer radius R_o of following figure. The dielectric constant of the shell is ε_r. **Determine all $\vec{E}$, V, $\vec{D}$ and $\vec{P}$ as functions of the radial distance *R*.**

(一) $R > R_o$ (5%)
(二) $R_i < R < R_o$ (10%)
(三) $R < R_i$ (5%)



Total: 20%

二、

(一) Consider two identical circular loops, each of radius b, carrying the same electric direct current I_0. The centers of the loops are at (0, 0, h) and (0, 0, $-h$) and the loops lie in the $z = h$ and $z = -h$ planes.
1. Calculate the magnetic flux density on the z-axis by using Biot-Savart law. (10%)
2. Plot $\vec{B}(z)$ by using your result in (a). (2%)

(二) For the source-free EM wave in free space,
1. Prove that

$$\nabla \cdot \vec{S} = -\frac{\partial}{\partial t}\frac{1}{2}\left(\vec{E}\cdot\vec{D} + \vec{B}\cdot\vec{H}\right)$$

where $\vec{S}$ is the Poynting vector, defined as $\vec{S} = \vec{E} \times \vec{H}$. (6%)
2. State the physical meanings of the proved equation. (2%)

Total: 20%

三、

(一) Obtain the wave equations governing the E and H fields in a source-free conducting medium with constitutive parameters ϵ, μ, and σ. (5%)
(二) What is meant by the polarization of a wave? When is a wave linearly polarized? Circularly polarized? (5%)
(三) What is meant by the wave impedance of the total field? When is this impedance equal to the intrinsic impedance of the medium? (5%)

Total: 15%

注意:背面有試題

參考用

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四、 The short-circuit and open-circuit impedances measured at the input terminals of a lossless transmission line of length $\ell = 1$ (m), which is less than a quarter wavelength, are $j150$ (Ω) and $-j50$ (Ω), respectively.

(一) Find the characteristic impedance and propagation constant of the line. (10%)

(二) Consider now, a short-circuited line with a new length of $2\ell = 2$ (m). The operating frequency remains unchanged.
1. Find the input impedance of this new short-circuited line. (5%)
2. Is this new length less or greater than a quarter wavelength? Explain your answer. (2%)

(三) How long should the short-circuited line be in order for it to appear as an open circuit at the input terminals? (3%)

You may find possible use of the following results:

$\tan(jA) = j\tanh A$; $\tanh(jA) = j\tan A$; $j\tanh^{-1} A = \tan^{-1}(jA)$; $\tanh^{-1}(jA) = j\tan^{-1} A$

$\tan\frac{\pi}{6} = \frac{1}{\sqrt{3}}$; $\tan\frac{\pi}{4} = 1$; $\tan\frac{\pi}{3} = \sqrt{3}$; $\sqrt{3} \approx 1.732$

Total: 20%

五、 Consider electromagnetic waves confined by a hollow rectangular metallic cavity of size $a \times b \times c$.

(一) Please clearly explain or prove why the method of separating variables can be used here. (5%)

(二) In terms of the complex representation (or the so-called harmonic fields), the time-dependent terms of electric field intensity $\boldsymbol{E}$ and magnetic field intensity $\boldsymbol{H}$ are called the phase terms. What are the phasor relationship between $\boldsymbol{E}$ and $\boldsymbol{H}$? Are all $\boldsymbol{E}$ in phase? Please clearly answer these problems. (5%)

(三) Based on the Maxwell's equations, derive the allowed $\boldsymbol{E}$ and $\boldsymbol{H}$ so concerned here. Here you are asked to solve the expressions for all spatial dependent functions of six components while omitting the coefficients, i.e., those constant terms, of these six components. (15%)

Total: 25%

注意：背面有試題

參考用