Physics Department
PHL110: Fields and Waves
I Semester : 2009-2010
Minor II

Attempt all questions. All subparts of a question should be done at one place. Answers to each question should start on a new page.

Max. Marks: 25

Duration: 1 hour

1. A pair of parallel metallic wires, of radii R each, are separated by d ($d >> R$). The wires carry current I in opposite directions.
   (a) Calculate the magnetic field, **B**, due to a single wire at (i) $r < R$, and (ii) $r > R$.
   (b) Calculate the total flux linked per unit length of the pair of wires, and hence
   (c) Calculate the inductance of the system.

(2+3+1)

2. A plane electromagnetic wave propagates in the x-z plane, at an angle 30° from $\hat{z}$, in a dielectric of relative permittivity $\varepsilon_r = 9$. At $\vec{r} = 0$ the electric field is $\vec{E}(\vec{r}=0,t) = (\hat{x}+\alpha\hat{z})A_o \cos\omega t$. Write (i) $\vec{E}(\vec{r},t)$, (ii) α, (iii) $\vec{B}(\vec{r},t)$, (iv) time average Poynting vector $\vec{S}_{av}$, and (v) an equation of the wavefront.

(7)

3. (a) An electromagnetic wave is incident normally from free space onto a dielectric (occupying z > 0 space). Inside the dielectric the transmitted electric field is

$$\vec{E}_T = \hat{x}Ae^{-i\left(\omega t - \frac{2\omega}{c}z\right)}$$

Obtain the electric fields of the incident and reflected waves.

(b) A cylindrical conductor of radius a and permeability μ carries uniformly distributed current I along z-direction.
(i) Find the magnetization **M** within the conductor.
(ii) Find the volume bound current density.

(4+4)

4. A steel ring has a mean radius of 10 cm and has a cross sectional area of 4 cm^2. A radial air-gap of length 1.5 mm is cut in the ring. If the relative permeability is 1250, calculate the mmf of the coil required to produce a magnetic flux of 500 μWb in the air gap. Also, state any assumption(s) you make.

(4)

Cylindrical. $d\mathbf{l} = ds\,\hat{\mathbf{s}} + s\,d\phi\,\hat{\boldsymbol{\phi}} + dz\,\hat{\mathbf{z}}; \quad d\tau = s\,ds\,d\phi\,dz$

Gradient : $$\nabla t = \frac{\partial t}{\partial s}\hat{\mathbf{s}} + \frac{1}{s}\frac{\partial t}{\partial \phi}\hat{\boldsymbol{\phi}} + \frac{\partial t}{\partial z}\hat{\mathbf{z}}$$

Divergence : $$\nabla \cdot \mathbf{v} = \frac{1}{s}\frac{\partial}{\partial s}(s v_s) + \frac{1}{s}\frac{\partial v_\phi}{\partial \phi} + \frac{\partial v_z}{\partial z}$$

Curl : $$\nabla \times \mathbf{v} = \left[\frac{1}{s}\frac{\partial v_z}{\partial \phi} - \frac{\partial v_\phi}{\partial z}\right]\hat{\mathbf{s}} + \left[\frac{\partial v_s}{\partial z} - \frac{\partial v_z}{\partial s}\right]\hat{\boldsymbol{\phi}} + \frac{1}{s}\left[\frac{\partial}{\partial s}(s v_\phi) - \frac{\partial v_s}{\partial \phi}\right]\hat{\mathbf{z}}$$

Laplacian : $$\nabla^2 t = \frac{1}{s}\frac{\partial}{\partial s}\left(s\frac{\partial t}{\partial s}\right) + \frac{1}{s^2}\frac{\partial^2 t}{\partial \phi^2} + \frac{\partial^2 t}{\partial z^2}$$