POSSESSION OF MOBILES IN EXAM IS UFM PRACTICE

Name of student ____________________ **Enrolment No.**____ ______

BENNETT UNIVERSITY, GREATER NOIDA

B.TECH/ TEST – Supplementary Examination: FALL SEMESTER A.Y. 2018-2019

COURSE CODE **EPHY105L/EPHY103L** MAX. TIME: **2 hours**
COURSE NAME : **Electromagnetics**
COURSE CREDIT: **3** MAX . MARKS: **100**

ALL QUESTIONS ARE COMPULSORY

1. Give brief answers with appropriate reasons to the following questions: **(8x4=32)**
   a) A positive charge of 1 μC is placed at the center of a cavity formed inside a *spherical conducting shell* having an inner radius 0.5 m and an outer radius 1 m. What is the electric field at a distance of 2 m from the center?
   b) A sphere of radius R carries a charge density given by $\rho(r) = \rho_0(1 - r^2/R^2)$. What is the value of $\nabla.\vec{E}$ at a point at a distance $R/4$ from the center?
   c) A charge Q is placed at the center of a dielectric sphere of radius R and uniform dielectric constant K. Use Gauss's law and obtain $\vec{D}$ within the sphere.
   d) Determine whether the vector function $\vec{G} = x^2\hat{x} - 2xy\hat{y}$ can represent a magnetic field.
   e) A cylindrical wire of radius R is carrying a current I which is uniformly distributed across its cross section. What is the value of $\nabla \times \vec{B}$ at a distance $2R$ from the axis?
   f) An infinitely long cylinder of circular cross section of radius R and length L is uniformly magnetized with magnetization $\vec{M} = M_0\hat{z}$ parallel to the axis of the cylinder. Obtain the corresponding bound surface current density on the cylindrical surface.
   g) What is the magnetic field corresponding to the following vector potential (written in cylindrical coordinates) $\vec{A} = k\hat{\phi}$ where k is a constant?
   h) An infinitely long straight solenoid having n turns per unit length with circular cross section of radius R and carrying a current I has a cylindrical rod of radius $R/2$ placed coaxially with the solenoid. Obtain the magnetic field $\vec{B}$ within the rod.

2. A dielectric material of dielectric constant K and thickness a is placed between the plates of a parallel plate capacitor separated by a distance $2a$. The free charge density on the upper plate is $+\sigma_f$ and that on the lower plate is - σ_f.
   a. Find the electric field $\vec{E}$ in the space between the plates, both within and outside the dielectric. **(8)**
   b. Obtain the electric polarization $\vec{P}$ in the dielectric slab. **(6)**
   c. What will be the bound surface charge density on the surface of the dielectric? **(2)**

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3. An infinitely long straight cylindrical wire of radius R made of a material with magnetic permeability μ carries a current I which is uniformly distributed across its cross section.
   a) Using Ampere's law, obtain the fields $\vec{H}$ and $\vec{B}$ in the regions $r < R$ and $r > R$. **(8)**
   b) Obtain the surface bound current and volume bound current in the wire. **(6)**
   c) What is the value of $\nabla \times \vec{B}$ at a distance $R/2$ from the axis of the cylinder? **(2)**

4. A uniform magnetic field $\vec{B} = B(t)\hat{z}$ exists in a cylindrical region of radius R with a time varying magnetic field given by $B(t) = B_0 \sin \omega t$. Assuming that the induced electric field due to the time varying magnetic field is along $\hat{\phi}$ direction (in cylindrical coordinates),
   a) Obtain the induced electric field $\vec{E}$ at a distance $r < R$ from the axis. **(6)**
   b) What will be the values of $\nabla . \vec{E}$ and $\nabla \times \vec{E}$ for $r < R$ and $r > R$? **(6)**

5. The voltage applied on a parallel plate capacitor with circular plates with radius R separated by a distance d and free space between the capacitor plates varies with time as $V(t) = V_0 \sin \omega t$.
   a) Obtain the displacement current density flowing between the plates of the capacitor. **(6)**
   b) Obtain the magnetic field between the plates of the capacitor at a distance $R/2$ from the axis **(4)**

   Given that the displacement current density is $\vec{J}_D = \epsilon_0 \frac{\partial \vec{E}}{\partial t}$ where symbols have their usual meaning.

6. An electromagnetic wave propagating in free space (velocity of the wave is 3×10^8 m/s) is described by the following expression for the electric field (x is measured in meters):
$$\vec{E} = E_0 \hat{y} \cos[2\pi(10^6 x + vt)]$$
   a) What are the values of frequency and wavelength of the wave? **(4)**
   b) What is the direction of propagation of the wave? **(4)**
   c) Given that the corresponding magnetic field of the wave is $\vec{B} = \vec{B}_0 \cos[2\pi(10^6 x + vt)]$, using Maxwell's equations obtain the magnitude and direction of $\vec{B}_0$. **(6)**

Some useful formulas

- In Cartesian coordinates:

$$\nabla f = \frac{\partial f}{\partial x}\hat{\imath} + \frac{\partial f}{\partial y}\hat{\jmath} + \frac{\partial f}{\partial z}\hat{k}$$

$$\nabla . \vec{F} = \frac{\partial F_x}{\partial x} + \frac{\partial F_y}{\partial y} + \frac{\partial F_z}{\partial z}$$

$$\nabla \times \vec{F} = \left[\frac{\partial F_z}{\partial y} - \frac{\partial F_y}{\partial z}\right]\hat{\imath} + \left[\frac{\partial F_x}{\partial z} - \frac{\partial F_z}{\partial x}\right]\hat{\jmath} + \left[\frac{\partial F_y}{\partial x} - \frac{\partial F_x}{\partial y}\right]\hat{k}$$

- In spherical polar coordinates:

$$\nabla f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial f}{\partial \phi}\hat{\phi}$$

$$\nabla . \vec{F} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 F_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial \theta}(\sin\theta\, F_\theta) + \frac{1}{r\sin\theta}\frac{\partial F_\phi}{\partial \phi}$$

$$\nabla \times \vec{F} = \frac{1}{r\sin\theta}\left[\frac{\partial}{\partial \theta}(\sin\theta\, F_\phi) - \frac{\partial F_\theta}{\partial \phi}\right]\hat{r} + \frac{1}{r}\left[\frac{1}{\sin\theta}\frac{\partial F_r}{\partial \phi} - \frac{\partial}{\partial r}(rF_\phi)\right]\hat{\theta} + \frac{1}{r}\left[\frac{\partial}{\partial r}(rF_\theta) - \frac{\partial F_r}{\partial \theta}\right]\hat{\phi}$$

- In cylindrical coordinates:

$$\nabla f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \phi}\hat{\phi} + \frac{\partial f}{\partial z}\hat{z}$$

$$\nabla . \vec{F} = \frac{1}{r}\frac{\partial}{\partial r}(rF_r) + \frac{1}{r}\frac{\partial F_\phi}{\partial \phi} + \frac{\partial F_z}{\partial z}$$

$$\nabla \times \vec{F} = \left[\frac{1}{r}\frac{\partial F_z}{\partial \phi} - \frac{\partial F_\phi}{\partial z}\right]\hat{r} + \left[\frac{\partial F_r}{\partial z} - \frac{\partial F_z}{\partial r}\right]\hat{\phi} + \frac{1}{r}\left[\frac{\partial}{\partial r}(rF_\phi) - \frac{\partial F_r}{\partial \phi}\right]\hat{z}$$

- $\epsilon_0 = 8.85 \times 10^{-12}$ $C^2/N\text{-}m^2$

- Maxwell's equations:

$$\nabla . \vec{E} = \frac{\rho}{\epsilon_0}$$

$$\nabla . \vec{B} = 0$$

$$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla \times \vec{B} = \mu_0 \vec{J} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t}$$