Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE UP SEMESTER EXAMINATIONS, JANUARY 2023

ELECTROMAGNETIC THEORY [ELE 2155]
REVISED CREDIT SYSTEM

Time: 3 Hours | **Date: 20th JANUARY 2023** | **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A.	Consider a vector $\overline{\boldsymbol{H}} = \left(\frac{A}{\rho}\right)\boldsymbol{a}_{\emptyset}$, where A is a constant and ρ is the radius of the cylinder. From the fundamental concepts, show the involved steps in transforming the vector $\overline{\boldsymbol{H}}$ to it equivalent in spherical coordinate system.	**(03)**
1B.	A unit normal vector from region-2 ($\mu = 3\mu_0$) to region-1 ($\mu = \mu_0$) is defined as $\boldsymbol{a}_{n21} = {(4\boldsymbol{a}_x + 4\boldsymbol{a}_y - 2\boldsymbol{a}_z)}/{6}$. If $\overline{\boldsymbol{H}}_1 = (20\boldsymbol{a}_x + 2\boldsymbol{a}_y + 12\boldsymbol{a}_z)$A/m, and $\overline{\boldsymbol{H}}_2 = (H_{2x}\boldsymbol{a}_x - 5\boldsymbol{a}_y + 4\boldsymbol{a}_z)$A/m, estimate the following parameters: • 'H'_{2x} • surface current density K on the interface. • The angles $\overline{\boldsymbol{B}}_1$ and $\overline{\boldsymbol{B}}_2$ make with the normal.	**(03)**
1C.	Let $D = 6xyz^2 a_x + 3x^2z^2 a_y + 6x^2yz a_z\ C/m^2$. Find the total charge lying within the region bounded by $x = 1\ and\ 3; y = 0\ and\ 1; z = -1\ and\ 1$ by separately evaluating each side of the divergence theorem.	**(04)**
2A.	With a neat diagram, explain and derive the expression for the induced electro motive force in a circuit that is in motion in a time varying magnetic field.	**(03)**
2B.	With a neat diagram, derive a suitable expression for the self-inductance of a coaxial cable of inner radius "a" and outer radius "b" if the space between the inner conductor and outer conductor is filled with an inhomogeneous material having $\mu = 2\mu_0/(1+\rho)$.	**(03)**
2C.	From the fundamentals, with a neat sketch, prove that, as per Poynting's theorem, the net power flowing out of a given volume is equal to the time rate of decrease in the energy stored within that volume minus the ohmic losses.	**(04)**
3A.	A toroidal core has an average radius of 10 cm with a cross sectional radius of 1 cm. If the core was made of steel ($\mu_R = 1000$) and the coil wound on it has 200 turns, calculate the amount of current that should flow to produce a magnetic flux of $0.5mWb$ in the core.	**(03)**

3B. Let $\bar{E} = (1000a_x + 400a_z)e^{-j10y}\ V/m$ for a 250 MHz uniform plane wave propagating in a perfect dielectric. If the maximum amplitude of the magnetic field intensity is 3 A/m, determine the following: ***(03)***

a) Relative permittivity of the dielectric
b) Relative permeability of the dielectric
c) $\bar{E}(x, y, z, t)$

3C. A lossy dielectric is characterized by $\varepsilon_R = 2.5, \mu_R = 4\ and\ \sigma = 10^{-3} S/m$ at 10 MHz. For a uniform plane wave propagating along the positive z-axis in the dielectric (having propagation constant = γ) at the said frequency, let $\bar{E} = 20e^{-\gamma z}a_x\ V/m$ at $z = 0$. Determine: ***(04)***

a) Attenuation constant	b) Phase constant	c) Wave velocity
d) Wavelength	e) Intrinsic impedance	f) $\bar{E}(2,3,4, t = 10ns)$

4A. From the basic concepts of Maxwell's equations, derive the wave equations along with expressions for its attenuation and phase constants for a uniform plane wave travelling in a linear, homogenous, charge free lossy dielectric medium ***(03)***

4B. In a medium ($\sigma = 0$; $\mu = 50\mu_0$; $\varepsilon = 4\varepsilon_0$), an electromagnetic wave is characterized by its $\bar{E}$ field as $\bar{\boldsymbol{E}} = 20\sin(10^8 t - \beta z)\boldsymbol{a_y}\ V/m$. Determine the following: ***(03)***

- Wave number
- The $\bar{\boldsymbol{H}}$ **field**
- Wave velocity

4C. In a non-magnetic medium, $\bar{E} = 4\ \text{Sin}\ (2\pi \times 10^7 t - 0.8x)a_z\ V/m$. ***(04)***

- Find ε_r, η
- The time average power carried by the wave
- The total power crossing $100cm^2$ of plane $2x + y = 5$

5A. A uniform plane wave in air is normally incident on an infinite lossless dielectric material having $\varepsilon = 3\varepsilon_0$ and $\mu = \mu_0$. If the incident wave is $\boldsymbol{E_i} = 10\cos(\omega t - z)\ \boldsymbol{a_y}\ V/m$ ***(03)***

Find

- The incident $\boldsymbol{H_i}$ field
- The reflection and transmission coefficients
- The total electric field in both regions

5B. For a uniform plane wave propagating along the positive z-axis as shown in **Fig. Q 5B**, assuming both the mediums to be perfect dielectrics, for a normal incidence, prove with appropriate explanations that: ***(03)***

a) $E_{ro}/E_{io} = \Gamma = [\sqrt{\varepsilon_1} - \sqrt{\varepsilon_2}]/[\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}]$
b) $H_{to}/H_{io} = \tau = [2\sqrt{\varepsilon_2}]/[\sqrt{\varepsilon_1} + \sqrt{\varepsilon_2}]$

5C. In free space ($z \leq 0$), a plane wave with $H_i = 10\cos(10^8 t - \beta z)\, a_x mA/m$ is incident normally on a lossless medium ($\varepsilon = 2\varepsilon_0, \mu = 8\mu_0$) in region $z \geq 0$. Determine the expressions for the reflected wave H_r, E_r as well as the transmitted wave H_t, E_t. ***(04)***

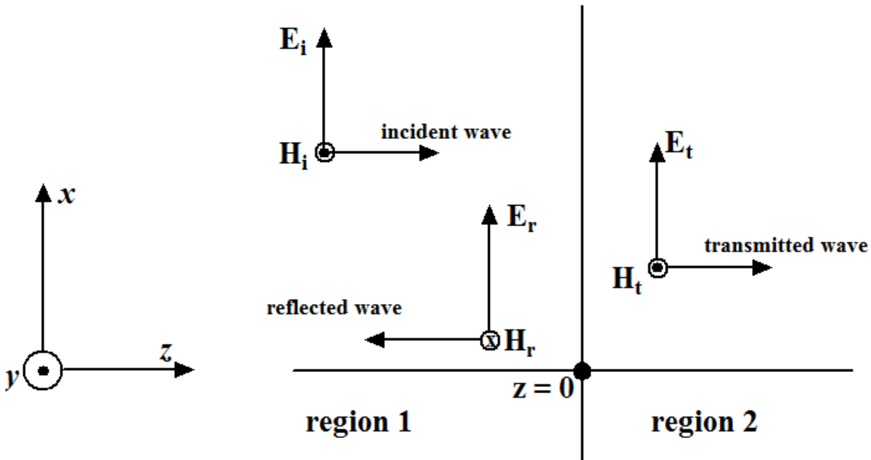

Fig. Q 5B