Reg. No.									

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

III SEMESTER B. TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, NOVEMBER 2019

ELECTROMAGNETIC THEORY [ELE 2155]
REVISED CREDIT SYSTEM

Time: 3 Hours | **Date: 26 November 2019** | **Max. Marks: 50**

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

1A. Given the following two fields $G_1 = 5(x+y)a_x + 10a_y$ and $G_2 = 5a_x + 2xya_y$. At a point $P(3, 2, 0)$ in space, determine the following: ***(03)***

a) The unit vector in the direction of G_1
b) The unit vector in the direction of G_2
c) The unit vector in the direction of $G_1 + G_2$

1B. From the fundamentals of co-ordinate systems, determine the following: ***(03)***

a) The volume defined by $4 < \rho < 6, 30^0 < \emptyset < 60^0, 2 < z < 5$.
b) The length of the longest straight line that lies entirely within the above defined volume.

1C. A coaxial capacitor has dimensions $a = 3mm, b = 12mm$, and a length of $1m$. The region between the conducting cylinders contains three different dielectrics: $\epsilon_{R1} = 5, (3 < r < 6mm$; $\epsilon_{R2} = 3, (6 < r < 9mm)$ and $\epsilon_{R3} = 1, (9 < r < 12mm)$. Calculate the overall capacitance 'C'. ***(04)***

Further, for $E_{r_{max}} = 100\ V/m$ prove that :

a) $E_{r1} = \left[{}^{0.18}/_{r}\right]$ for $3 < r < 6mm$;
b) $E_{r2} = \left[{}^{0.3}/_{r}\right]$ for $6 < r < 9mm$
c) $E_{r3} = \left[{}^{0.9}/_{r}\right]$ for $9 < r < 12mm$

2A. With a neat diagram, state Stoke's theorem. Let a certain magnetic field intensity in free space be given as follows: ***(03)***

$$\bar{H} = \frac{20(x)a_x + 20(y)a_y}{(x^2 + y^2)} A/m$$

Prove that $\nabla.\bar{B} = 0$ where $\bar{B} =$ the magnetic flux density

2B. Consider $z = 0$ as the interface between two charge free regions. The region $z < 0$ contains a perfect dielectric for which $\epsilon_{R1} = 2.5$, while the region $z > 0$ is characterized by $\epsilon_{R2} = 4$. Let $E_1 = -30a_x + 50a_y + 70a_z\ V/m$. Determine: ***(03)***

a) The angle $\theta_1 < 90^0$ between E_1 and normal to the surface.
b) The angle $\theta_2 < 90^0$ between E_2 and normal to the surface

2C. The magnetic field intensity in a certain region is given as: ***(04)***

$$\bar{H} = \left(\frac{x+2y}{z^2}\right) a_y + \frac{2}{z} a_z \ A/m$$

a) Determine the current density vector $\bar{J}$

b) Using the above current density, also determine the total current flowing through the surface $z = 4; 1 < x < 2; 3 < y < 5$ in a_z direction.

3A. A point charge $Q = -40\ nC$ is travelling at a velocity of $6 \times 10^6 m/s$ in a direction specified by the unit vector $a_v = -0.48a_x - 0.6a_y + 0.64a_z$ in an electromagnetic field system comprising of $\bar{E} = 2a_x - 3a_y + 5a_z\ kV/m$ and $\bar{B} = 2a_x - 3a_y + 5a_z\ mT$. Determine the magnitude of the force experienced by the point charge due to the electro-magnetic field system. ***(03)***

3B. The core of a toroid has a cross sectional area of 12 cm^2 and is made of a material having relative permeability of 200. If the mean radius of the toroid is 50 cm, calculate the number of turns needed to obtain an inductance of 2.5 H. ***(03)***

3C. State and derive (with appropriate explanations) Poynting theorem and show that total power leaving a volume is equal to rate of decrease in energy stored in electric and magnetic fields minus the ohmic power dissipated ***(04)***

4A. A uniform plane wave $\bar{E} = 50\sin(\omega t - 5x)a_y V/m$ in a lossless medium $(\mu = 4\mu_0,\ \varepsilon = \varepsilon_0)$ encounters a lossy medium $(\mu = \mu_0,\ \varepsilon = 4\varepsilon_0, \sigma = 0.1S/m)$ normal to the x-axis. Determine the expressions of the reflected wave $(E_r\ and\ H_r)$ ***(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 $\boldsymbol{E} = 20\sin(10^8 t - \beta z)\boldsymbol{a_y}\ V/m$. Determine the following: ***(03)***

a) Wave number b) The $\bar{\boldsymbol{H}}$ **field** c) Wave velocity

4C. With suitable diagrams, derive the expressions for reflection and transmission coefficients in plane wave shielding theory. Hence, prove that, the shielding effectiveness of an infinite sheet of good conductor is dependent on the reflection loss as well as absorption loss. ***(04)***

5A. A 30 GHz radar signal may be represented as a uniform plane wave in a sufficiently small region. Calculate the wavelength and the attenuation constant if the wave propagates in a non-magnetic medium for which: ***(03)***

a) $\varepsilon_R = 1\ and\ \sigma = 0$ b) $\varepsilon_R = 1.01\ and\ \sigma = 10^{-3}\mho/m$ c) $\varepsilon_R = 2.1\ and\ \sigma = 5\mho/m$

5B. With the help of a neat diagram, derive Snell's law for a uniform plane wave incident at oblique angles to the interface between two perfect dielectrics having refractive indices n_1 (for region 1) and n_2 (for region 2). ***(03)***

5C. Using the fundamentals of oblique incidence of a prallelly polarized uniform plane wave at an interface z=0 between two perfect dielectrics, prove that: ***(04)***

$$i)\ \frac{E_{ro}}{E_{io}} = \frac{\eta_2\cos\theta_t - \eta_1\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i}$$

$$ii)\ \frac{E_{to}}{E_{io}} = \frac{2\eta_2\cos\theta_i}{\eta_2\cos\theta_t + \eta_1\cos\theta_i}$$

Where $\theta_t =$ angle of refraction; $\theta_i =$ angle of incidence.