Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
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III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
GRADE IMPROVEMENT/ MAKEUP EXAMINATIONS, JULY/AUGUST 2021

ELECTROMAGNETIC THEORY [ELE 2155]

REVISED CREDIT SYSTEM

Time: 2 Hours **Date: 30th July, 2021** **Max. Marks: 40**

Instructions to Candidates:
- ❖ Answer **ANY FOUR FULL** questions.
- ❖ Missing data may be suitably assumed.

1A. From the fundamentals of co-ordinate systems, determine the following:
- The volume defined by $4 < \rho < 6, 30^0 < \emptyset < 60^0, 2 < z < 5$.
- The length of the longest straight line that lies entirely within the above-defined volume. ***(05)***

1B. 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'.

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 $9 < r < 12mm$ ***(05)***

2A. Determine the total charge in a volume defined by six planes for which $1 \le x \le 2; 2 \le y \le 3; 3 \le z \le 4$ if $\overline{\boldsymbol{D}} = 4x\boldsymbol{a_x} + 3y^2\boldsymbol{a_y} + 2z^3\boldsymbol{a_z}\ C/m^3$.

Further, considering a current density of $J = \dfrac{2(x+2y)}{z^3}\boldsymbol{a_x} + \dfrac{1}{z^2}\boldsymbol{a_z}$;

Determine the total current **I** passing through the surface $1 \le x \le 2; 2 \le y \le 3; z = 4$ in the z-direction ***(05)***

2B. Region 1 described by $3x + 4y \ge 10$ is free space while region 2 described by $3x + 4y \le 10$ is a magnetic material for which $\mu = 10\mu_0$. Assuming that boundary between the material and free space is current free, for $B_1 = 0.1a_x + 0.4a_y + 0.2a_z\ Wb/m^2$ find $H_1, B_2\ and\ H_2$. ***(05)***

3A. 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. ***(05)***

3B. A current filament carrying 8 A in the a_z direction lies along the entire z-axis in free space. A rectangular loop connecting $A(0, 0.2, 0)$ to $B(0, 0.2, 0.3)$ to $C(0, 0.7, 0.3)$ to $D(0, 0.7, 0)$ to A lies in the $x = 0$ plane. The loop current is 3 mA and it flows in the a_z direction in the AB segment. Determine the force acting on:
- Side AB
- Side DA
- Side CD

(05)

4A. A perfectly conducting filament containing a 500Ω resistor is formed into a square as shown in **Fig. Q 4A**. determine the flowing current in the loop if the existing magnetic field is given by:

$B = 2\cos[3\pi \times 10^8(t - {}^{x}/_{c})]a_z\ \mu T$ where $c = 3 \times 10^8\ m/s$

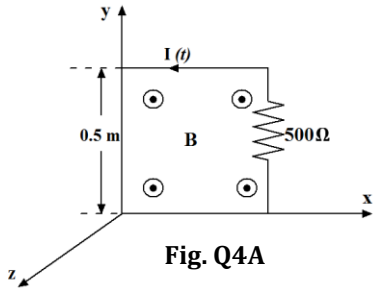

Fig. Q4A

(05)

4B. Assume a homogenous material of infinite extent having the following properties: $\sigma = 0;\ \varepsilon = 2 \times 10^{-10} F/m\ and\ \mu = 1.25 \times 10^{-5}\ H/m.$

Let $\bar{E} = 400\cos(10^9 t - kz)a_x\ V/m$. If all the fields vary sinusoidally (or cosinusoidally), using Maxwell's equations determine:

- The electric flux density
- Magnetic flux density and field intensity
- k

(05)

5A. A certain medium has its conductivity $(\sigma) = 0$ and relative permeability $(\mu_R) = 1$. A uniform plane wave defined by $\bar{E}(z,t) = 800\sin(10^6 t - 0.01z)a_y\ V/m$ propagates through it in the a_z direction. Using Maxwell's equations, determine the following:

- The magnetic field intensity $\bar{H}(z,t)$
- The relative permittivity ε_R
- The intrinsic impedance of the medium.

(05)

5B. With a neat diagram and appropriate explanations, derive the expressions for reflection and transmission co-efficients when a uniform plane-wave, propagating along the +z-axis, is incident normally on an interface $(at\ z = 0)$ between two different media. ***(05)***

6A. A plane wave of 16 GHz frequency and $\bar{E} = 10\ V/m$ propagates through a body of salt water defined by the relative permittivity and relative permeability of 100 and 1 respectively. The conductivity of the medium is assumed to be100 S/m. Determine the following parameters:

- Attenuation constant
- Phase constant and phase velocity
- Intrinsic impedance of the medium
- Depth of penetration of the wave in the medium.

(05)

6B. Using the fundamentals of oblique incidence of a prallelly polarized uniform plane wave at an interface z=0 between two perfect dielectrics, prove that:

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

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

Where $\theta_t =$ angle of refraction; $\theta_i =$ angle of incidence. ***(05)***