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

III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
MAKE-UP EXAMINATIONS, DECEMBER 2018
SUBJECT: ELECTROMAGNETIC THEORY [ELE 2104]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 31, December 2018** **Max. Marks: 50**

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

1A. Given $\overline{\boldsymbol{A}} = 2\boldsymbol{a_x} + 6\boldsymbol{a_y} - 3\boldsymbol{a_z}$ and $\overline{\boldsymbol{B}} = -3\boldsymbol{a_x} - 4\boldsymbol{a_y} - 5\boldsymbol{a_z}$, find

- A unit vector in the direction of $(\overline{\mathbf{A}} - \overline{\mathbf{B}})$
- The magnitude of $(\overline{\mathbf{A}} + \overline{\mathbf{B}})$
- $\left|(\overline{\boldsymbol{A}} + 3\overline{\boldsymbol{B}})\Big/|\overline{\boldsymbol{A}} + 3\overline{\boldsymbol{B}}|\right| . \overline{\boldsymbol{B}}$

(03)

1B. With a neat diagram and suitable explanations, derive the expression for the electric field intensity at a point 'P' which is at a distance 'h' meters above a straight finite length, uniformly charged wire having a charge density of +λ coulomb per meter length. Also determine the electric field intensity if the point 'P' under consideration is along the perpendicular bisector of the charged wire. ***(03)***

1C. A circular disc of radius 'a' is uniformly charged with ρ_s C/m^2. If the disc lies on the $z = 0$ plane with its axis along the $z - axis$, prove that at point $(0,0,h)$:

$$E = \frac{\rho_s}{2\varepsilon_0}\left\{1 - \frac{h}{(h^2 + a^2)^{1/2}}\right\} a_z V/m$$

(04)

2A. A thin circular ring of radius $'\boldsymbol{a}'$ has a total charge $' + \boldsymbol{Q}'$ distributed uniformly over it.

- Derive the expression of the electric field intensity at point P which is $'x'$ meters from the centre on the axis of the ring
- Determine the force on a charge $'q'$ at the point P which is $'x'$ meters from the centre on the axis of the ring
- Determine the force on the charge $'q'$ placed at the centre of the ring

(03)

2B. 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 $\overline{D} = 4x\boldsymbol{a_x} + 3y^2\boldsymbol{a_y} + 2z^3\boldsymbol{a_z}\ C/m^3$.

Further, considering a current density of $J = \frac{2(x+2y)}{z^3}\boldsymbol{a_x} + \frac{1}{z^2}\boldsymbol{a_z}$; 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 ***(03)***

2C. The plane $z = 0$ separates air $(z \ge 0, \mu = \mu_0)$ from iron $(z \le 0, \mu = 200\mu_0)$. Given that: $\overline{\boldsymbol{H}} = 10a_x + 15a_y - 3a_z\ A/m$, in air:

a) Determine the magnetic flux density in iron.
b) Calculate the angle between the field vector and the interface in iron. ***(04)***

3A. If $\overline{\mathbf{H}} = (4z - y)\mathbf{a_x} + 6xz\mathbf{a_y}$ A/m, then from the appropriate fundamentals, determine the current density $(\overline{\mathbf{J}})$ and current $(\boldsymbol{I})$ passing through the plane $y = 2;\ -2 < x < 2; 1 < z < 3$. ***(03)***

3B. A solenoid of length '***l***' and radius '***a***' consists of '***N***' turns of wire through which current '***I***' flows. With a neat diagram and suitable explanation, prove that at point '***P***' along its axis, $\boldsymbol{H} = {}^{[nI(cos\theta_2 - cos\theta_1)]}/_{2}\, a_z$

Where: $n = N/l$, θ_1 and θ_2 are the angles subtended at P by the end turns. ***(03)***

3C. In a certain region of space, $\bar{B} = 0.1xa_x + 0.2ya_y - 0.3za_z\ T$. Determine the total force on a rectangular loop as shown in **Fig. Q3C**, if it lies in the $z = 0$ plane and is bound by $x = 1; x = 3;\ y = 2\ and\ y = 5\ cm$. ***(04)***

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:
$B = 2\sin[120\pi t]a_z\ T$ ***(03)***

4B. With appropriate explanations, derive 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 ***(03)***

4C. 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:

a) Relative permittivity of the dielectric
b) Relative permeability of the dielectric
c) $\bar{E}(x, y, z, t)$ ***(04)***

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: ***(03)***

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

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. ***(03)***

5C. 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 $= \gamma$) at the said frequency, let $\bar{E} = 20e^{-\gamma z}a_x\ V/m$ at $z = 0$. Determine:

a) Attenuation constant b) Phase constant c) Wave velocity
d) wavelength e) Intrinsic impedance f) $\bar{E}(2,3,4, t = 10ns)$ ***(04)***

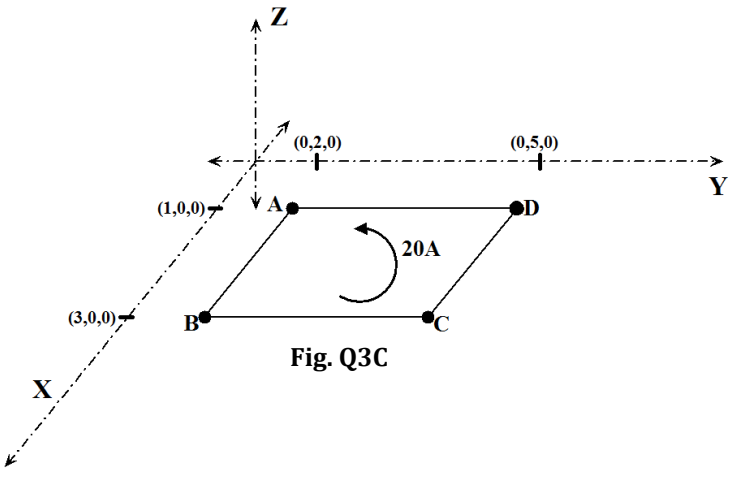

Fig. Q3C

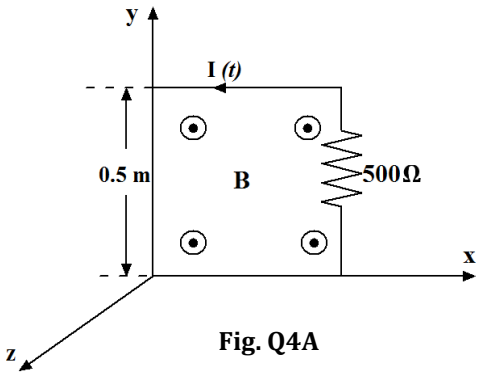

Fig. Q4A