Reg. No.									

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

III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, NOVEMBER 2018
SUBJECT: ELECTROMAGNETIC THEORY [ELE 2104]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 29, November 2018** **Max. Marks: 50**

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

1A. Given $\bar{A} = 2\boldsymbol{a_x} + 6\boldsymbol{a_y} - 3\boldsymbol{a_z}$ and $\bar{B} = -3\boldsymbol{a_x} - 4\boldsymbol{a_y} - 5\boldsymbol{a_z}$, find
- A unit vector in the direction of $(\bar{A} - \bar{B})$
- The magnitude of $(\bar{A} + \bar{B})$
- $\left| (\bar{A} + 3\bar{B}) \big/ |\bar{A} + 3\bar{B}| \right| . \bar{B}$ ***(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. Identical $1\mu C$ point charges are located in free space at (0,0,1) and (0,0,−1). Prepare a plot depicting the variation of $|\bar{E}|$ v/s z; along the line is $x = 0, y = 2, for\ 0 \le |z| \le 5$ in increments of 0.5 units. **(Use the graph sheet provided)** ***(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 $\bar{D} = 4x\boldsymbol{a_x} + 3y^2\boldsymbol{a_y} + 2z^3\boldsymbol{a_z}\ C/m^2$. ***(03)***

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

2C. 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 $\bar{B}_1 = 0.1a_x + 0.4a_y + 0.2a_z\ Wb/m^2$ find $\bar{H}_1, \bar{B}_2\ and\ \bar{H}_2$. ***(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 so as to produce a magnetic flux of $0.5mWb$ in the core. ***(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, $\bar{H} = [nI(\cos\theta_2 - \cos\theta_1)]/2\, a_z$

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

3C. 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 as shown in **Fig Q3C**. Determine the forces acting on all sides of the loop ***(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:

$\bar{B} = 0.2 \cos[120\pi t] a_z\, T$ ***(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. 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 and k
- Magnetic flux density and field intensity ***(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:

- The magnetic field intensity $\bar{H}(z, t)$
- The relative permittivity ε_R and the intrinsic impedance of the medium. ***(03)***

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 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 be 100 S/m. Determine the following attributes:

- Attenuation constant, phase constant and phase velocity
- Intrinsic impedance of the medium and the depth of penetration in the medium ***(04)***

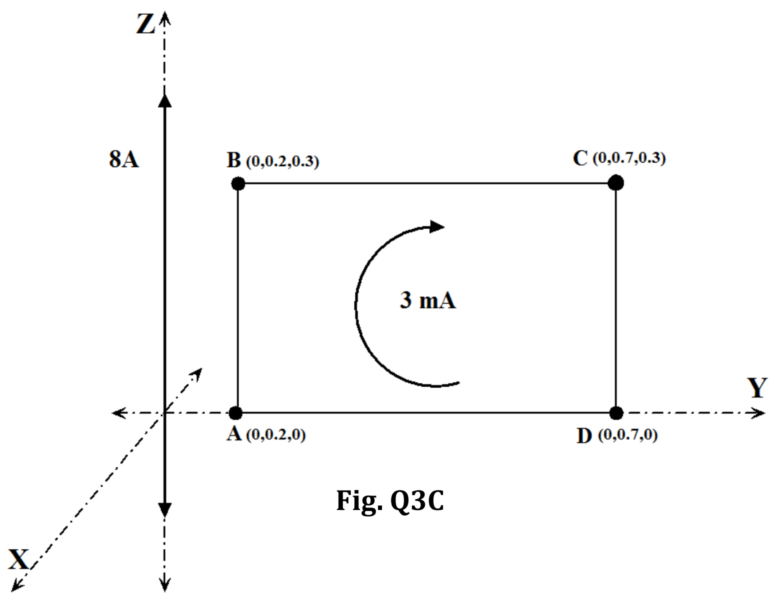

Fig. Q3C

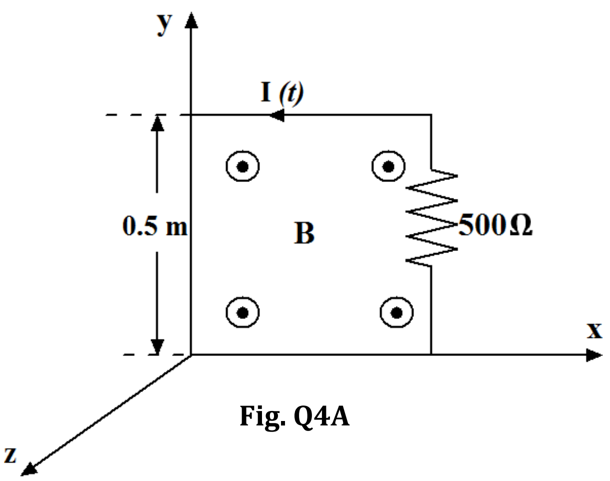

Fig. Q4A