Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

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A Constituent Institution of Manipal University

III SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

MAKEUP EXAMINATIONS, DEC 2016 - JAN 2017

SUBJECT: ELECTROMAGNETIC THEORY [ELE 2104]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 04 January 2017** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Graph sheets shall be supplied, if required

1A. State Coulomb's law of electrostatic force of attraction/repulsion.
A point charge $Q_1 = 10\mu C$, is located at $P_1(1,2,3)$ in free space, while $Q_2 = -5\mu C$ is at $P_2(1,2,10)$. Find the vector force exerted on Q_2 by Q_1. Also determine, the coordinates of P_3 where a point charge Q_3 experiences no force. ***(03)***

1B. With neat diagram, derive the expression for the electric field intensity at a point situated above a uniformly charged circular disc along its axis having a charge density of 'σ C/m^2'.
Further, deduce the electric field intensity for the disc to be infinitely long having the same charge density. ***(03)***

1C. In free space, let $Q_1 = 10nC$ be at $P_1(0,-4,0)$, and $Q_2 = 20nC$ be at $P_2(0,0,4)$.

- Determine the electric field intensity at the origin.
- Where should a $30nC$ point charge be located so that the electric field intensity is zero at the origin?

(04)

2A. Let $\rho_v = 8z(1-z)C/m^3$ for $(0 < z < 1m)$, $\rho_v = 8z(1+z)C/m^3$ for $(-1 < z < 0)$ and zero for $(|z| > 1)$.

- Determine the electric flux density everywhere.
- Plot the variation of $D_z\ vs\ 'z', for(-2 < z < 2m)$ (**use the graph sheet**)

(03)

2B. A perfect dielectric ($\varepsilon_{r1} = 2.5$) fills the region 1 (z< 0) while the region 2 (z> 0) is characterized by ($\varepsilon_{r2} = 4$). For an electric field $E_1 = -30a_x + 50a_y + 70\,a_z$ V/m, Determine:

- The electric flux density D_2
- The angles -- θ_1 and θ_2.

Let the vector E_2 make an angle of $\theta_2 < 90^0$ with the normal to the surface while $\theta_1 < 90^0$ is the angle E_1 makes with the normal to the surface. ***(03)***

2C. A parallel plate capacitor has a plate separation distance of 't'. The capacitance with air only between the plates is 'C'. When a slab of thickness 't_1' and relative permittivity 'ϵ_R' is placed on the bottom plate, the capacitance is 'C_1'. Show that –

$$\frac{C_1}{C} = \frac{\epsilon_R * t}{t_1 + \epsilon_R(t - t_1)}$$

(04)

3A. State Biot-Savart's law for determination of the magnetic field due to a current element.

With a neat diagram derive an expression for the magnetic field intensity, at the center of a circular wire having radius 'a' and carrying a current 'I' in the anti-clockwise direction. Consider the circular loop to be on the XY-plane. ***(03)***

3B. With a neat diagram, state stoke's theorem. Let a certain magnetic field intensity in free space be given as:

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

Show that $\nabla . B = 0$. Also determine the current density. ***(03)***

3C. With neat diagram, derive and explain the expressions for the induced electro motive force where the magnetic flux through a circuit changes with time and the circuit is in motion as well. ***(04)***

4A. There exists a boundary between two magnetic materials at $z = 0$ having permeabilities $\mu_1 = 4\mu_0$ H/m and $\mu_2 = 7\mu_0$H/m for region 1 ($z > 0$) and region 2 ($z < 0$) respectively. For a field $B_1 = (2a_x - 3a_y + 2a_z)mT$ in region 1, determine the flux density B_2 in region 2. Also determine the angle made by B_2 with the normal to the interface. ***(03)***

4B. With a neat diagram, explain and derive a suitable expression for the self-inductance of a coaxial line with a solid inner conductor. Assume the radius of the inner conductor to be $'a'$. ***(03)***

4C. A stationary 10 turn square coil of 1 meter side is situated with its lower left corner co-incident with the origin. The sides $x_1 and\ y_1$ are along the X and Y axes respectively. If the magnetic flux density is normal to the plane of the coil and has its amplitude given by:

$$|B| = \sin\left(\frac{\pi x}{x_1}\right) \sin\left(\frac{\pi y}{y_1}\right) T$$

Determine the r.m.s value of the emf in the coil for a co-sinusoidal harmonic variation of the magnetic flux density at a frequency of 1KHz. ***(04)***

5A. A wave propagating in a lossless dielectric has the components $E = 500\cos(10^7 t - \beta z)\, a_x\, V/m\ and\ H = 1.1\cos(10^7 t - \beta z)\, a_y\, A/m$. If the wave is travelling at a velocity of $1.5 \times 10^8\ m/s$, determine:

- The relative permittivity and relative permeability of the dielectric medium.
- The phase constant of the wave.
- The wavelength of the propagating wave.
- The intrinsic impedance of the dielectric medium. ***(03)***

5B. 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:

- $\varepsilon_R = 1\ and\ \sigma = 0$
- $\varepsilon_R = 1.01\ and\ \sigma = 10^{-3}\mho/m$
- $\varepsilon_R = 2.1\ and\ \sigma = 5\mho/m$ ***(03)***

5C. From the fundamentals, with 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)***