Roll No.:.....

National Institute of Technology, Delhi

Name of the Examination: B.Tech. / M.Tech. / Ph.D. (Make-Up)

Branch	**: ECE**	**Semester**	**: 3rd**
Title of the Course	**: Electromagnetic Theory**	**Course Code**	**: ECL203**

Time: 3 Hours **Maximum Marks: 50**

Note: Read the given instructions for each section
Assume suitable data, if found missing.
Used symbols have their usual meaning.

Section A: Attempt all questions; each question is of one (01) mark

Q1. The amplitude of the electric field intensity on the surface of a good conductor is E_0. The amplitude of the field at a depth equal to the skin depth is - (1)

Q2. $E_x = E_{x0}\cos(\omega t - \beta z)$ is a solution of the one dimensional wave equation for sinusoidally time varying fields. The phase velocity of the wave is - (1)

Q3. Write the continuity equation. (1)

Q4. The unit of Poynting vector is..... (1)

Q5. A potential function is given by $ax^3 + bxy^2$, where a and b are constants. The function will satisfy Laplace's equation if ..... (1)

Q6. The radius of a circular conductor is 'a'. It carries a uniformly distributed current of density J A/m^2. The magnetic field intensity at a radius $r < a$ is given by ..... (1)

Q7. The SI unit of electric conductivity is ..... (1)

Q8. The volume charge density in a region is defined by $re^{-r}\sin^2\theta$ in spherical coordinates. The divergence of electric flux density at r = 0.5, $\theta = 60^\circ$ is ..... (1)

Q9. Two point charges $+Q$ and $-2Q$ are located at $x = -a$ and $x = a$ respectively. The potential is zero at ....(1)

Q10. The angle between two vectors $A = 3\boldsymbol{u}_x + 4\boldsymbol{u}_y$ and $B = p\boldsymbol{u}_x + q\boldsymbol{u}_y$ is 15^o. What is the ration of p to q? (1)

Section B: Attempt any four (04) questions. Each question is of 5 marks

Q1. Write Maxwell's equations in differential and integral form along with their physical explanation. Also write the name of each Maxwell's equation. (5)

Q2. (a) A hollow spherical shell carries charge density $\rho = k/r^2$ in the region $a \le r \le b$. Find the electric field in the three regions: (i) r < a, (ii) a < r < b (iii) r > b. Plot |E| as a function of r. (3)

(b) Given that $D = z\rho\cos^2\phi a_z\ C/m^2$, calculate the charge density at *(1, pi/4, 3)* and the total charge enclosed by the cylinder of radius *1m* with $-2 \le z \ge 2\ m$. (2)

Q3. (a) Derive the wave equations in terms magnetic vector potential and electric scalar potential. (4)

(b) Given that $A = 10\cos(10^8 t - 10x + 60^o)a_z$ express A in phasor form. (1)

Q4. (a) Determine the dot product of the position vectors of the following two points: A(5, 53.13°, 1) and B(2, 90°, -5). (2)

(b) Explain the term polarization. Derive the expression for the potential in-terms of volume bound charge density and surface bound charge density. (3)

Q5. Drive the expression of wave propagation in lossy dielectrics. (5)

Section C: Attempt any two (02) questions. Each question is of 10 marks

Q1.(a) The point charge Q = 18nC has a velocity of 5×10^6 m/s in the direction $a_v = 0.04a_x - 0.05a_y + 0.2a_z$. Calculate the magnitude of the force exerted on the charge by the field: (6)

(i) $B = -3a_x + 4a_y + 6a_z$ mT (ii) $E = -3a_x + 4a_y + 6a_z$ kV/m (iii) B and E together (4)

(b) Derive the expression for α, β, and η for the wave propagation in lossy dielectrics.

Q2.(a) Two spherical cavities, of radii a and b, are hollowed out from the interior of a (neutral) conducting sphere of radius R. At the center of each cavity a point charge is placed – the charges are q_a and q_b. (2)

(1) Find the surface charges σ_a, σ_b, and σ_R. (2)

(ii) What is the field outside the conductor? (1)

(iii) What is the force on $q_a$andq_b. (5)

(b) Explain following terms:

(a) Biot-Savart Law (b) Stokes' Theorem (c) Magnetic Potential

(d) Faraday Law of EMI (e) Skin depth

Q3. (a) A uniform plane wave propagating in a medium has $E = 2e^{-\alpha z}sin(10^8 t - \beta z)a_y$ V/m. If the medium is characterized by $\varepsilon_r = 1$, $\mu_r = 20$, and $\sigma = 3$ S/m, find α, β, and H. (5)

(b) Derive the expression for displacement current density. (3)

(c) The ratio J/J_d (conduction current density to displacement current density) is very important at high frequencies. Calculate the ration at 1 GHz for – distilled water ($\mu = \mu_o$, $\varepsilon = 81\varepsilon_o$, $\sigma = 2\times 10^{-3}$ S/m) (2)