Roll No.:.....

National Institute of Technology, Delhi

Name of the Examination: B. Tech. / M. Tech. / Ph.D.

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

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

Note : Read the given instructions for each section

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

Q1. In a uniform plane wave E and H are related by –

(i) $\frac{E}{H} = \sqrt{\frac{\mu}{\varepsilon}}$ (ii) $\frac{E}{H} = \sqrt{\frac{\varepsilon}{\mu}}$ (iii) $\frac{E}{H} = \frac{\mu}{\varepsilon}$ (iv) $\frac{E}{H} = \frac{\varepsilon}{\mu}$ (1)

Q2. An EM wave incident on a perfect conductor is –

(i) fully transmitted (ii) entirely reflected (iii) partially reflected (iv) none of the above (1)

Q3. In a perfect dielectric, wave propagation occurs – (i) with small attenuation (ii) with large attenuation (iii) with zero attenuation (iv) none of the above (1)

Q4. The value of $\sqrt{\frac{\mu}{\varepsilon}}$ for a free space is about –

(i) 380 Ω (ii) 38 Ω (iii) 3.8 Ω (iv) 3800 Ω (1)

Q5. The work done in carrying a charge 'q' once round a circle of radius 'r' with a charge Q at the centre is ..... (1)

Q6. Why doesn't we see the portion other than visible one of the EM spectrum? (1)

Q7. On what factors the velocity of electromagnetic wave depend? (1)

Q8. Write the dimensional formula for ε_0. (1)

Q9. Does Coulomb's law of electric force obeys Newton's third law of motion? (1)

Q10. When placed in a uniform field, a dipole experiences only ..... (1)

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

Q11. (a) Planes $x = 2$ and $y = -3$, respectively, carry charges $10\ nC/m^2$ and $15\ nC/m^2$. If the line $x = 0, z = 2$ carries charge $10\pi\ nC/m$, calculate E at $(1, 1, -1)$ due to the three charge distributions. (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 $-2 \leq z \geq 2\ m$. (2)

Q12. (a) Three point charges are located as shown in figure 1, each a distance 'a' from the origin. Find the approximate electric field at points far from the origin. Express your answer in spherical coordinates, and include the two lowest orders in the multi-pole expansion. (3)

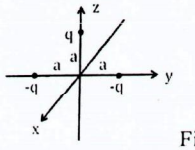

Figure 1

(b) A dielectric cube of side 'a', centered at the origin, carries a frozen-in polarization P = kr, where k is a constant. Find all the bound charges, and check that they add up to zero. (2)

Q13. (a) Find the force on a square loop placed as shown in figure 2, near an infinite straight wire. Both the loop and the wire carry a steady current *I*. (2)

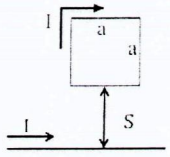

Figure 2

(b) State Ampere's circuit law and write it's differential and integral form. (1)

(c) Let plane $z = 0$ and $z = 4$ carry current $K = -10a_x$ A/m and $K = 10a_x$ A/m respectively. Determine $\boldsymbol{H}$ at $(1, 1, 1)$ and $(0, -3, 10)$. (3)

Q14. (a) Show that the boundary conditions between two magnetic media on the magnetization vector are - $\frac{M_{1t}}{\chi_{m1}} - \frac{M_{2t}}{\chi_{m2}} = K$ and $\frac{\mu_1}{\chi_{m1}} M_{1n} = \frac{\mu_2}{\chi_{m2}} M_{2n}$ (3)

(b) If the boundary is not current free, show that we obtain - $\frac{\tan\theta_1}{\tan\theta_2} = \frac{\mu_1}{\mu_2}\left[1 + \frac{K\mu_2}{B_2 \sin\theta_2}\right]$ (2)

Q15. (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)

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

Q16. (a) Conducting spherical shells with radii $a = 10$ cm and $b = 30$ cm are maintained at a potential difference of 100 V such that $V(r = b)$ and $V(r = a) = 100V$. Determine V and E in the region between the shells. If $\varepsilon_r = 2.5$ in the region, determine the total charge induced on the shells and the capacitance of the capacitor. (5)

(b) Derive the expression of continuity equation. Also determine the boundary conditions in between two different dielectric media. (5)

Q17. (a) Given a uniform plane wave in air as $E_i = 40\cos(\omega t - \beta z)a_x + 30\sin(\omega t - \beta z)a_y$ V/m

(i) Find H_i

(ii) If the wave encounters a perfectly conducting plate normal to the z-axis at $z = 0$, find the reflected wave E_r and H_r.

(iii) What are the total E and H fields for $z \leq 0$?

(iv) Calculate the time-average Poynting vectors for $z \leq 0$ and $z \geq 0$. (6)

(b) Derive the expression for α, β, and η for the wave propagation in lossy dielectrics. (4)

Q18. (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)