Registration No.: | | | | | | | | | | |

Total Number of Pages: 02 **Course: B.Tech**

Sub_Code: REC4C001

4th Semester Back Examination: 2024-25

SUBJECT: Electromagnetic Theory

BRANCH(S): ECE, ETC

Time: 3 Hours

Max Marks: 100

Q.Code: S592

Answer Q1 (Part-I) which is compulsory, any eight from Part-II and any two from Part-III.

The figures in the right hand margin indicate marks.

Part-I

Q1 **Answer the following questions:** **(2 x 10)**

a) What is the physical significance of Curl of a given function?

b) Given a vector A = $2a_z + 4a_y + 10a_z$. Express it in cylindrical coordinate system.

c) What is the significance of the field equation $\nabla.\mathbf{B} = 0$?

d) Define scalar and vector magnetic potential. What are their units?

e) Differentiate between convection current and displacement current

f) Differentiate the linear and circular polarizations.

g) Why was it necessary to modify Ampere's law for time varying fields? Mention the modified equation.

h) Find the skin depth at a frequency of 1.6 MHz in aluminium where the conductivity is 38.2 MS/m and the value of relative permeability is unity.

i) An airline has characteristic impedance of 85 Ω and phase constant of 3 rad/m at 100 MHz. Calculate the inductance per meter of the line.

j) Define the transmission line parameters.

Part-II

Q2 **Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve)** **(6 x 8)**

a) Explain Gauss's law in electrostatics in differential and integral form. What are its applications?

b) Show that the electric field at a point (0, 0, h) due to the rectangle developed by $-a \le x \le a$, $-b \le y \le b$, $z = 0$ carrying uniform charge density ρ_s C/m^2 is,

$$\mathbf{E} = \frac{\rho_s}{\pi\varepsilon_o} \tan^{-1}\left[\frac{ab}{h(a^2+b^2+h^2)^{\frac{1}{2}}}\right]\boldsymbol{a_z}$$

c) Describe the Coulomb's law and find the expression for electrical field intensity E due to an infinite line charge situated along the z-axis.

d) A charge distribution in space has $\rho_v = 2r$ nC / m^3 for $0 \le r \le 10$ m and zero otherwise. Determine E at $r = 2$ m and $r = 12$ m

e) What do you mean by boundary condition? Derive the boundary conditions for conductor and dielectric interface.

f) For a typical copper wire of diameter 2.5 mm and conductivity 4 x 10^7 S/m has 10^{29} free electrons per cubic meter when an electric field of 13 mV/m is applied. Determine:
(I) The current density
(II) The current in the wire
(iii) The drift velocity of the electrons.

g) Briefly explain the law of conservation of magnetic flux and derive the Maxwell fourth equation using neat sketch.

h) State Ampere's circuital law and apply this to determine $\overrightarrow{H}$ on the x-axis of a circular current loop of radius a, if an infinite long filamentary current I flows along z axis.

i) Draw the E field and H field pattern of TE wave in rectangular waveguide. A standard air-filled rectangular waveguide with dimensions a = 8.636 cm and b = 4.318 cm is fed by a 4-GHz carrier from a coaxial cable. Determine whether a TE_{10} mode will be propagated or not. If so, calculate the phase velocity and the group velocity.

j) An air-filled planar line with w = 30 cm, d = 1.2 cm, t = 3 mm has conducting plates with σ_c = 7 x 10^7 *S / m*. Calculate R, L, C, and G at 500 MHz.

k) What is dominant mode of a waveguide? Mention dominant mode for rectangular waveguide and circular waveguide.

l) Discuss about radiation resistance and radiation intensity concerned with a Hertzian dipole. Is the radiation resistance, ohmic resistance of the dipole wire? Justify your answer.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four) **(16 x 2)**

Q3 Which law is established concerned with forces between two-point charges? Write the mathematical expression for the electric field intensity. Derive the expression for each component of field intensity **E** at a test charge ***ΔQ*** due to a point charge ***Q***. Find E at point ***P*** (0.5 m, –0.7 m, 1.0 m) due to the two point charges Q_1 = 5 nC and Q_2 = –3 nC located at P_1 (–1.0 m, 0.8 m, 2.0 m) and P_2(2.0 m, 1.0 m, –1.0 m) respectively in free space. **(16)**

Q4 Derive all the four Maxwell's Equations and express in both point and integral form. **(16)**

Q5 Considering a uniform plane wave incident normally on a perfect conductor, find the fields of incident and reflected waves, total electric and magnetic fields, and surface current density. A uniform plane wave travelling along the positive z direction in air incident normally on a perfect conducting surface located at the z = 0 plane. The E of the incident wave is $\overline{E}_0^+ = (200u_x + 150u_y)e^{-j\beta z}$. Obtain
(a) the E of the reflected wave, (b) the H of the incident wave, (c) the H of the reflected wave, and (d) current density on the conductor surface. **(16)**

Q6 Obtain the circuit model of a long two-conductor transmission line. The radii of the inner and outer conductors of a coaxial transmission line are 2.0 mm and 4.0 mm respectively. The conductivity of the conductors (σ_c) is 5.8 × 10^7 S/m. The ε_r, μ_r, and conductivity (σ_d) of the insulation between the conductors are 3.5, 1.0, 6.0 × 10^{-8} S/m respectively. Find the series resistance, inductance, capacitance, and shunt conductance per unit length of the line at a frequency of 150 KHz. Considering these parameters, calculate also the phase constant, phase velocity, and wavelength of the voltage wave. **(16)**