Department of ECE

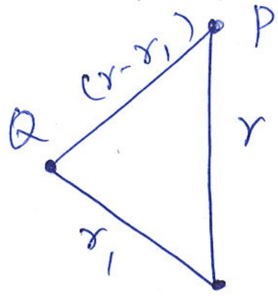
18ECC105T - Electromagnetics & Transmission Lines.

Unit - I

1. Given point $P(-2, 6, 3)$ and vector $\vec{A} = y\vec{a_x} + (x+2)\vec{a_y}$ express 'P' & 'A' in cyclindrical & spherical coordinates. Evaluate 'A' at 'P' in cartesian, cyclindrical and spherical system. (12 marks)

2. Find the electric field at point $P(r = 2, \theta = 25^\circ, \phi = 90^\circ)$ if $\vec{D} = 0.3\,r^2\vec{a_r}$ in free space. (4 marks).

3. Find the electric field intensity at $P(-4, 6, -5)$ in free space caused by a charge of 0.3mc at $(2, -1, -3)$. (4 marks)



4. Let $\vec{D} = 6xyz^2\vec{a_x} + 3x^3z^2\vec{a_y} + 6x^2yz\vec{a_z}$ c/m. Find the total charge lying within the region bounded by $x = 1$ & $x = 3$, $y = 0$ & $y = 1$,

$z = -1$ & $z = +1$ by seperately evaluating each side of the divergence theorem. (4 marks).

5. Find the gradient of the following fields

(a) $V = e^{-z} \sin 2x \cosh y$ (4 marks)

(b) $U = \rho^2 z \cdot \cos 2\phi$ (4 marks)

(c) $W = 10r \sin^2\theta \cos\phi$ (4 marks)

6. Given that $\vec{D} = z\rho \cos^2\phi\, \vec{a_x}$ c/m^2. Calculate the charge density at $(1, \pi/4, 3)$ and the total charge enclosed by the cylinder of radius 1m with $-2 \leq z \leq 2m$ (4 marks)

7. If $\vec{D} = (zy^2 + z)\vec{a_x} + 4xy\, \vec{a_y} + x\, \vec{a_z}$ c/m^2

Find (i) the volume charge density at $(-1, 0, 3)$

(ii) The flux through the cube defined by $0 \leq x \leq 1$, $0 \leq y \leq 1$, $0 \leq z \leq 1$. (4 marks)

8. The finite sheet $0 \leq x \leq 1$, $0 \leq y \leq 1$ on the $z = 0$ plane has a charge density $\rho_s = xy(x^2 + y^2 + 25)^{3/2}$ nc/m^2. Find (a) total charge on the sheet. (b) electric field at $(0, 0, 5)$ (c) force experienced by a $-1mc$ charge located at $(0, 0, 5)$ (12 marks)

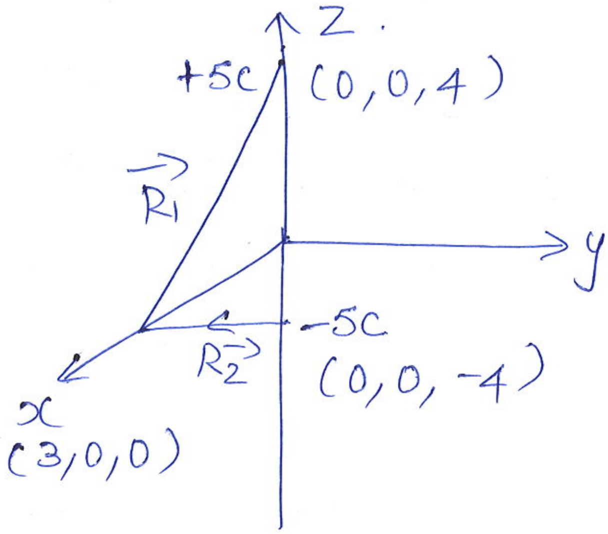
8. The point charges 1nC, 4nC, 3nC are located at (0,0,0) (0,0,1) and (1,0,0). Find the energy of the system. (4 marks)

9. Given the potential $V = \frac{10}{r^2} \sin\theta \cos\phi$.

(a) Find the $\vec{D}$ at $(2, \pi/2, 0)$

(b) Calculate the workdone in moving a work charge from point $A(1, 30^\circ, 120^\circ)$ to $B(4, 90^\circ, 60^\circ)$. (12 marks).

10. Find the total electric field intensity at (3,0,0). (4 marks)



11. Find an appropriate value for the total charge enclosed in an increased volume of $10^{-9}\,m^3$ located at origin of $\vec{D} = e^{-x} \sin y\, \vec{a_x} - e^{-x} \cos y\, \vec{a_y} + 2z\, \vec{a_z}$ c/m^2

(4 marks)

12. Two point charges $Q_1 = 50\mu c$ and $Q_2 = 10\mu c$, are located at $P(-1, 1, 3)$ & $P_2(3, 1, 0)$ respectively. Find the force on Q_1 due to Q_2. (4 marks)

13. $V = 50(x^2+y^2+z^2)$ volts. Find the magnitude and direction of electric field intensity at $(1, -1, 1)$. (4 marks)

14. Two point charges $-4\mu c$ and $5\mu c$ are located at $(2, -1, 3)$ and $(0, 4, -2)$ respectively. Find the potential at $(1, 0, 1)$. Assuming zero potential at infinity. (4 marks)

15. Check validity of the divergence theorem, considering the field $\vec{D} = 2xy\vec{a_x} + x^2\vec{a_y}$ c/m^2 and the rectangular parallo piped formed by the plates $x=0, x=1$; $y=0, y=2$; $z=0$; $z=3$. (12 marks)

16. The vector form of coloumbs law by locating a charge of $Q_1 = 3\times10^{-4}$ c at $M(1,2,3)$ and charge of $Q_2 = -10^{-4}$ c at $N(2,0,5)$ in vaccum. Derive the force exerted on Q_2 by Q_1. (4 marks)

17. 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 $P_2(1,2,10)$.
(a) Find the vector force exerted on 'Q_2' by 'Q_1'
(b) Find the coordinates of 'P_3' at which a point charge Q_3 experiences no force. (12 marks)

Unit - II

1. Planes $z=0$ & $z=4$ carry current $k = -10\vec{a_x}$ A/m and $k = 10\vec{a_x}$ A/m respectively. Determine 'H' at (a) $(1,1,1)$ (b) $(0,-3,10)$. (4 marks)

2. A parallel plate capacitor with plate area of $5\ cm^2$ and plate seperation of 3 mm has a voltage $50 \sin 10^3 t$ (v) applied to its plate. Calculate the displacement current assuming $\epsilon = 2\epsilon_0$. (4 marks)

Unit - III

1. A lossy dielectric has an intrinsic impedance of $200\angle 30^\circ\ \Omega$ at a particular radian frequency 'ω'. If at that frequency the plane wave propagating through the dielectric has the magnetic field component $H = 10e^{-\alpha x}\cos(\omega t - \frac{1}{2}x)\vec{a_y}$ A/m. Find 'E' & 'α'. Determine skin depth and wave polarization. (12 marks)

2. A uniform plane wave propagating in a medium has $E = 2e^{-\alpha z}\sin(10^8 t - \beta z)\vec{a_y}$ V/m. If the medium is characterized by $\varepsilon_r = 1$, $\mu_r = 20$, $\sigma = 3$ S/m. Find α, β and H (12 marks)

3. In a rectangular waveguide for which $a = 1.5$ cm; $b = 0.8$ cm; $\sigma = 0$; $\mu = \mu_0$; $\varepsilon = 4\varepsilon_0$, $\beta = 1$. The waveguide is operating in TM_{13} mode. $H_x = 2\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{3\pi y}{b}\right)\sin(\pi \cdot 10^{11} t - \beta z)$ A/m. Determine (i) cut off frequency (ii) phase constant (iii) propagation constant. (4 marks)

4. A standard air filled rectangular waveguide $a = 8.636$ cm ; $b = 4.318$ cm is fed by 4 GHz carrier from a co-axial cable. Determine whether TE_{10} mode will be propagated. If so, calculate the phase velocity and group velocity. (4 marks)

5. A rectangular waveguide has internal dimensions 2 cm × 1 cm and is propagated at a 10 GHz signal in the dominant mode (TE_{10}). Find the guided wavelength and wave impedance. (4 marks)

6. A rectangular metal waveguide filled with a dielectric material of relative permitivity $\epsilon_r = 4$ has the inside dimension 3 cm × 1.2 cm. Find the cutoff frequency for the dominant mode. (4 marks)

7. An air filled rectangular waveguide has inner dimensions of 3 cm × 2 cm. Find the wave impedance of the TE_{20} mode of propagation in the waveguide at a frequency

of 30GHz. ($\eta_0 = 377\,\Omega$) $\rightarrow$ free space impedance.
(4 marks)

8. A coaxial cable with an inner diameter of 1mm and outer diameter of 2.4mm is filled with a dielectric of relative permitivity 10.89. Find the characteric impedance. (4 marks)

9. The electric field component of a time harmonic plane EM wave travelling in a non-magnetic lossless lossless dielectric medium has an amplitude of 1 V/m. If the relative permitivity of the medium is 4, find the magnitude of the time average power density vector in (w/m²). (4 marks)

10. A rectangular waveguide of internal dimension a = 4cm; b = 3cm is to be operated in TE_{11} mode. Find the minimum operating frequency. (4 marks)

11. In a medium, characterized by $\sigma = 0$, $\mu = \mu_0$ and $\epsilon = \epsilon_0$ and $E = 20\sin(10^8 t - \beta z)\vec{a_y}$ V/m. Calculate 'β'. (4 marks)

12. Give the relation between guide wavelength (λg), cutoff wavelength (λc) and free space wavelength (λ_0) of a waveguide. (4 marks)

Unit - IV

Transmission Lines.

1. An air line has a characteristic impedance of 70 Ω and phase constant of 3 rad/m at 100 MHz. Calculate the inductance per meter and the capacitance per meter of the line. (4 marks)

2. A transmission line operating at 500 MHz has $Z_0 = 80\,\Omega$, $\alpha = 0.04$ Np/m, $\beta = 1.5$ rad/m. Find the line parameters R, L, C & G. (12 marks)

3. A distortionless line has $Z_0 = 60\,\Omega$; $\alpha = 20$ m Np/m; $u = 0.6c$ where 'c' is the speed of light in a vaccum. Find R, L, C, G and λ at 100 MHz. (12 marks)

4. An open wire telephone line has $R = 10\,\Omega$/km, $L = 0.0037$ H/km, $C = 0.0083 \times 10^{-6}$ F/km, $G = 0.4 \times 10^{-6}$ mho/km. Determine its characteristic impedance and propagation constant. (4 marks)

5. A telephone line has $R = 30\,\Omega$/km; $L = 100$ mH/km, $C = 20\,\mu$F/km, $G = 0$. At $f = 1$ kHz

obtain (a) the characteristic impedance of the line (b) the propagation constant (c) the phase velocity. (6 marks).

6. A transmission line has the following parameters. $R = 2\,\Omega/m$; $G = 0.5\,\Omega/m$; $f = 1GHz$ $L = 8\,mH/m$; $C = 0.23\,pf$. Calculate the impedance and propagation constant. (4 marks)

Unit - V

1. Determine the following (a) Standing wave ratio (b) load admittance. (4 marks)

A Transmission line with a characteristic impedance of $300\,\Omega$ and terminated in a load of $175 + j207\,\Omega$. An electrical signal of 200 MHz is transmitted along the line in free space.

2. A transmission line 100m long is terminated in a load of $(100 - j200\,\Omega)$. Determine the line impedance at 25 m from the load end at a frequency of 10MHz. Assume $Z_0 = 100\,\Omega$ and $V = 3 \times 10^8$ m/s. Use smith chart. (4 marks).

3. Using smith chart find the sending end impedance of a line with negligible losses when $Z_0 = 55\,\Omega$ and $Z_R = 115 + j75\,\Omega$. Length of the line is 1.123 its wavelength. ($L = 1.183\lambda$)
(4 marks)

4. Determine the load impedance and SWR for distance 0.21λ from the load towards generator with a characteristic impedance $Z_0 = 50\,\Omega$ and load impedance, $Z_L = 80 - j30\,\Omega$.
(4 marks)

5. Determine the stub length and the distance of the stub from the load. Given that a complex load $Z_L = 50 - j100$ is to be matched to a $75\,\Omega$ transmission line using smith chart short circuited stub. (12 marks)

~~6. Draw a straight line from~~

6. A transmission line of characteristic impedance Z_0 is terminated by Z_R. Derive the expression for the position of attachment & length of a short circuited stub (single) which will remove the standing waves on a large

portion of transmission. (12 marks)

7. A transmission line has $Z_0 = 300\,\Omega$ and terminated is a load $150 + j150\,\Omega$. Find the following using smith chart.
(i) VSWR (ii) Reflection coefficient (iii) impedance at a distance of 0.1λ from the load. (iv) position of first voltage minimum from the load (12 marks)

8. A load of $(50 - j100)\,\Omega$ is connected across a $50\,\Omega$ line. Design a short circuit stub in order to provide impedance matching between the two at a single frequency of 30 MHz. (12 marks)

9. Transmission line with characteristic impedance of $300\,\Omega$ and terminated in a load of $175 + j207\,\Omega$. An electrical signal of 200 MHz is transmitted along the line in free space. Determine the following (i) SWR (ii) load admittance (iii) distance between load and first voltage minimum. (12 marks)

~~10. Transmission line with characteristic impedance of 300Ω and terminated in a load of 175 + j207 Ω.~~

10. Determine the following.

(a) Load admittance

(b) Standing wave ratio.

(c) impedance of transmission line at maximum and mimum of the stationary wave along the line.

(d) Distance between load and first maximum for a transmission line with characteristics impedance of 50Ω with a receiving end impedance of 100 + 121j. The wavelength of the electrical signal along the line is 2.5 m. (12 marks)

11. A lossless tx line with $Z_0 = 50\Omega$ is 30m long and operates at 2 MHz. The line is terminated with a load $Z_L = 60 + j40\Omega$. If $u = 0.6c$ on the line find the reflection coefficient, standing wave ratio, input impedance. (12 marks)

12. A load of $100+j150\,\Omega$ is connected to $75\,\Omega$ lossless line. Find

(a) Reflection coefficient - Γ

(b) Standing wave ratio - S

(c) load admittance - Y_L

(d) Z_{in} at 0.4λ from the load

(e) location of V_{max} and V_{min} w.r.t the load if the line is 0.6λ length.

(f) Z_{in} at the generator. (12 marks).

13. A certain transmission line has a characteristic impedance of $75+j0.01\,\Omega$ and is terminated in a load impedance of $70+j50\,\Omega$. Compute (a) reflection coefficient (b) transmission coefficient. (4 marks).