Subject Name: Electro Magnetic Waves & Fields (EMWF)

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Unit-I: (Electrostatics)

Important points / Definitions:

IMPORTANT POINTS

UNIT 1

1. The frequency at which the wave motion ceases is called Cutoff frequency.

2. A Lumped load line behaves as a Low pass filter

3. By inserting inductance in series with the line to increase the inductance is called Loading.

4. One Neper is = 8.68 dB.

5. A short circuited λ/4 line can be used a Insulator

6. The range of UHF is 300 MHz to 3 Ghz

7. The loading practice is generally restricted to Cables only.

8. When a transmission line is shorted, the first voltage minimum occurs at Load

9. The center of smith chart represents Matched load impedance.

10. Attenuation factor of TEM wave is proportional to Square root. of frequency.

UNIT I

I. LONG ANSWER QUESTIONS [10M]

1 (a) State coulomb's law in vectorial form and list out its applications and limitations.

(b) A charge, Q1 = -10 nC is at the origin in free space. If the x-component of E is to be zero at the point (3, 1, 1), what charge, Qt should be kept at the point (2, 0, 0)?

2 (a) Explain the concept of electric field intensity.

(b) A point charges of 500 _c each are placed at the corners of a square of $3\sqrt{2}$ m side. The square is located in the Z = 0 plane between x □□□□^{3} m in free space. Find the force on a point charges of 30 µc at (0, 0, 4) m.

3 a) State and explain Coulomb‘s Law.

b) List and explain applications integral of Gauss‘s Law.

4 A parallel plate capacitor has a plate area of separation of 5mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3mm with of 6 and the second has a thickness of 2mm with relative permittivity 4. Find the capacitance?

5 a) State and explain Gauss_s law.

b) Four concentrated charges Q1 = 0.3 µ c, Q2 = 0.2 µc, Q3 = -0.3 µc, Q4 = 0.2 µc are located at the vertices of a plane rectangle. The length of rectangle is 5 cm and breadth of the rectangle is 2 cm. Find the magnitude and direction of resultant

6 (a) Derive the concept of electric field intensity from Columb‘s law.

(b) Derive an expression for electric field intensity at any point _P‘ at a radial height _h‘ from a finite line charge of λ c/m. extending along the z-axis from 32 to 33 distance _P‘ in the x-y plane.

7 (a) State and explain Coulomb_s law of electrostatic field in vector form.

(b) It is required to hold four equal point charges to each in equilibrium at the corners of a square. Find the point charge, which will do this if placed at the center of the square.

8 (a) Explain coulomb_s law.

(b) Two small identical conducting spheres have charge of 2nC and -0.5nC respectively. When they are placed 4 cm apart what is the force between them. If they are brought into contact and then separated by 4 cm what is the force between them.

9 Define the Laplacian Equation for Cartesian coordinates and harmonic condition in a region.

Short Answer Questions

1 State coulomb's law in vectorial form and list out its applications and limitations

2 Define Stokes Theorem.

3 Define Gauss Law and Poisson Equation.

4 Define Electric Field Intensity

5 Give the relationship between the D and E
6 List out the application of Guass law.
7 Define Permitivity and Permeability.
8 Give the relationship between the D , V and F.

OBJECTIVE QUESTIONS:

UNIT-1

1. (1) For a good conductor

a) ζ = infinity , $\zeta << w\varepsilon$, b) $\zeta = 0$, $\zeta >> w\varepsilon$, c) $\zeta = 1$, $\zeta << w\varepsilon$, (d) $\zeta = 0$, $\mu = \mu_r$

(2) The skin depth or penetration depth is having expression
a) $\delta = 1/\beta$ (b) $\delta = 1/\alpha + i\beta$ (c) $\delta = 1/\alpha$ (d) $\delta = 0$

(3) A uniform plane wave propagating in a medium has E = $2\, e^{-az}$ sin (10^8 t - βz) ay V/m. If the medium is characterized by $\varepsilon_r = 1$, $\mu_r = 20$, and $\sigma = 3$ mhos/m, find α

(a) 61.4 Np/m, (b) 71.4 Np/m (c) 51.4 Np/m (d) 80 Np/m

(4) What is the relation between $\theta\eta$ and θ is

(a) $\theta\eta = 2\theta$ (b) $\theta\eta = \theta$ (c) $2\,\theta\eta = \theta$ (d) $1/2\,\theta\eta = \theta$

(5) The displacement current is expressed by

(a) $I_d = \int J_d . ds$ (b) $I_d = J_d . ds$ (c) $I_d = dJ_d / dt$ (d) $I_d = J_d / ds$

(6) The wavelength can be expressed as

(a) $\lambda = 2\pi\beta$ (b) $\lambda = 2\pi/\beta$ (c) $\lambda = 2\pi/c$ (d) $\lambda = \beta/2\pi$

(7) A standing wave

a) Progresses with less than light velocity b) progresses with more than light velocity

c) progresses with equal to light velocity d) does not progress.

(8) The range of reflection coefficient is

a) 0 to 1 b) 0 to infinity c) -1 to 1 d) 1 to infinity

(9) As per the boundary condition,

a) The normal component of E is continuous across the boundary.

b) The tangential component of E is continuous across the boundary.

c) The tangential component of D is continuous across the boundary.

d) The normal component of H is continuous across the boundary

10. Hysteresis and eddy current losses in loading coils leads to

a) Increase in L b) Decrease in L c) Increase in R d) decrease in R

UNIT 2 (Magnetostatics)

IMPORTANT POINTS

1. The relation between E and H in any medium

2) The value of intrinsic impedance of free space is 377Ω
3) In a perfect dielectric medium attenuation constant is Zero

4) The loss tangent value for a good conductor is (σ/ωε)>>1

5) A wave propagating in a conducting medium attenuation constant and phase constant

values

6) The conductivity of silver is 3x106 mho/m.If the skin depth is 1mm, the frequency is 84.43kHz

7) the expression for reflection coefficient of a perfect dielectic surface when the wave incident normal to the boundary is TR =(η2-η1)/(η2+η1)

8) The Poynting vector physically denotes the power density leaving or entering a given volume in a time-varying field

9) Brewster angle θB when the wave is parallally polarized is

10) Critical angle θc for the total internal reflection is

UNIT II

I. LONG ANSWER QUESTIONS [10M]

1 A conducting filament carries current I from point A (0, 0, a) to point B(0, 0, b). show that at point P(x, y, 0).

$$H = \frac{1}{4\pi}\left[\frac{b}{\sqrt{x^2+y^2}\sqrt{x^2+y^2+b^2}} - \frac{a}{\frac{x}{2}\sqrt{y^2+a^2}}\right]a$$

An infinitely long conducting filament is placed along the x axis and carries current 10 mA in the a_x direction. Find H at (-2, 3, 3).

2 Write down the Maxwell's equations for Static Electric and Magnetic fields with remarks

3 Write the short notes on Biot Savart's Law and Ampere's Circuit Law with required equations.

4 Derive the third Maxwell equation using Ampere's Law and explain two applications of Ampere's Law.

5 Derive with neat diagram the special case of BIOT SAVART Law when the conductor is infinite in length

6 Calculate H at (3m, -6m, 2m) due to a current element of length 2 mm located at the origin in free space that carries current 16 mA in the +y direction

7 (a) Describe the characteristics of vector magnetic potential.
(b) If the vector magnetic potential with in a cylindrical conductor of radius _a' $A = \frac{\mu_o I r^2}{4\pi a^2} a_z$, find H.

8 A conductor of length 100 cm moves at right angles to uniform field of strength 10000 lines per cm^2 with a velocity of 50 m/s. Calculate emf induced in it when the conductor moves at an angle 300 to the direction of the field.

9 a) Explain behavior of conductors in an electric field.
b) A dipole at the origin in free space has P = 95Πε $_0$U z C-m. Find (a) V at P(x.y,z) in Cartesian coordinate.
c) E at P(x,y,z) in Cartesian coordinate.

10 a) Explain the concept of electric field intensity.

b) A point charges of 500 µC each are placed at the corners of a square of m side. The square is located in the Z = 0 plane between m in free space. Find the force on a point charges of 30 µC at (0, 0, 4) m.

11 a) Derive an expression for the electric field intensity due to an infinite length line charge along the z-axis at an arbitrary point Q (x, y, z).

b) A charge of -0.3µC is located at A (25, -30, 15) Cm and a second charge of 0.5 µ C is located at B (-10, 8, 12) Cm. Find the electric field strength, E at: i. The origin and ii. Point P (15, 20, 50) cm.

12 Establish Gauss Law in point form and integral form hence deduce the Laplace_s and Poissions_s equations.

13 Show that the torque acting on an dipole of movement p due to an electric field E is p×E Compute the torque for a dipole consisting of 1

μc charges in an electric field E = 103 (z a_x − a_y − a_z) separated by 1 mm and located on the z-axis at the origin.

14 (a) Prove the Maxwell's equation $\nabla .B = 0$.

(b) If H = 10 cos (10^{10}t − βx) a_z A/m, find B, D, E and β when μ = 1.2×10^{-10} *F* / *m* , 2×10^{-5} H/m ζ = 0.

15 A parallel plate capacitor has a plate area of 1.5 sq.m and a plate separation of 5mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3mm with a relative permittivity of 6 and the second has a thickness of 2mm with relative permittivity 4. Find the capacitance?

16 a) Derive an expression for Ohm's Law in Point form.

b) Find the relative permittivity of dielectric material used in parallel capacitor if C =45nF, d = 0.4mm and S =0.35 m^2. (b) d = 0.6 mm, E =700 kv/m and ρ =35 μ C/m 2, D =75 μC/m 2 and energy density is 35 J/m^3.

17 (a) Using Ampere's Circuital law, find the magnetic field intensity in the case of a closely wound torroidal coil.

(b) A single-phase circuit comprises two parallel conductors A and B, each 1 cm diameter and spaced 1 m apart. The conductors carry currents of +100 and -100 amps respectively. Determine the field intensity at the surface of each conductor and also in space exactly midway between A and B.

18 (a) Explain duality between D and J

(b) Find the total current in a circular conductor of radius 4 mm if the current density varies according to J = 104A/m2.

19 A parallel plate capacitor has a plate area of 1.5 sq.m. and a plate separation of 5 mm. There are two dielectrics in between the plates. The first dielectric has a thickness of 3 mm with a relative permittivity of 6 and the second has a thickness of 2 mm with relative permittivity 4.Find the capacitance. Derive the formula uses.

20 (a) For a pure dipole paz C- m at the origin in free space, find the potential at a point A

(b) What is the electric field at (x=0,y=0,z=5m) due to a pure dipole 1a_z μc-m at the origin?

21 Calculate the capacitance of a parallel plate capacitor with following details.

Plate area = 150 sq.cm. Dielectric εr1 = 3, d12 = 4mm Dielectric εr2 = 5, d12 = 6 mm. If 200 V is applied across the plates what will be the voltage gradient across each dielectric.

UNIT II

I. SHORT ANSWER QUESTIONS

1 Define the magnetic field dH at point due to current element I dI.
2 Name three boundary conditions related to materials.
3 Define the Maxwell equations in integral form.
4 State the BIOT-SAVART'S Law (dH or H) in Line and surface current.
5 Define Maxwell equations in the Differential form.
6 Name two applications of AMPERE'S Law in symmetrical conditions
7 Describe Conductor Dielectric Boundary Condition.
8 Define continuity equation and derive relaxation time equation?

MULTIPLE CHOICE

1. Transverse magnetic (TM) waves have
   a. Magnetic field component H in the direction of propagation
   b. Electric field component E in the direction of propagation
   c. Magnetic field component H in the direction of propagation and no component of electric field E in this direction
   d. Electric field component E in the direction of propagation and no component of magnetic field H in this direction.
2. The velocity of electromagnetic wave in a good conductor is

   a. 3 x 10^8 m/s b. more than 3 x 10^8 m/s c. very low d. High

3. A uniform plane wave is one in which

   a x = 0 b . c. and are perpendicular d and lie in a plane

4. The Depth of penetration of EM wave in medium having conductivity ζ at a frequency of 1
   MHz is 25 cm. The depth of penetration at a frequency of 4 MHz will be

   A. 6.25 cm B. 12.50 cm C. 50 cm D. 100 cm

5. In a 100 turn coil, if the flux through each turn is $(t^3 - 2t)m\text{W}_b$, the magnitude of the induced emf in the coil at a time of 4 sec is

   A. 46 mV B. 56 mV C. 4.6 V D. 5.6 V

6. In a conductor which of the following relations hold good?

   A. ∇ x D = r B. ∇ . D = r C. ∇ x D = 0 D. ∇ . D = 0

7. A material has conductivity of 10^{-2} mho/m and a relative permittivity of 4. The frequency at which conduction current in the medium is equal to displacement current is
   A.45 MHz B.90 MHz C.450 MHz D. 900 Mhz

8. For static magnetic field Maxwell's curl equation is given by

   A. $\nabla . \vec{B} = \mu_0 \vec{J}$ B. $\nabla \times \vec{B} = 0$ C. $\nabla \times \vec{B} \mu_0 \vec{J}$ D. $\nabla \times \vec{B} = \mu_0 / \vec{J}$

9. Which one of the following statement is not a correct for a plane wave with $\vec{H} = 0.5e^{-0.1x}$ cos ($10^6 t$ - $2x)a_z$ A/m

   A. The wave frequency is 10^{-6} r.p.s. B. The wavelength is 3.14 m

   C. The wave travels + *x* direction D. Wave is polarized in the *z* direction.

10. A uniform plane wave is one in which
    A. x = 0 B. . C. and are perpendicular, D. and lie in a plane