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Question Bank

Year/Semester: II/ IV **Date: 21/02/2025**	**Department : ECE** **Subject Code/Title : EC3452 / Electromagnetic Fields** **Faculty Name : Ms.D.Ragavi**	**Unit :** I,II,III,IV,V **Section : Part A/B/C**

UNIT I

UNIT I INTRODUCTION

PART A

1. **Define scalar quantity ? (R)**

   A field is a system in which a particular physical function has a value at each and every point in that region. The distribution of a scalar quantity with a defined position in a space is called scalar field.

   Ex: Temperature of atmosphere.

2. **Define vector field? (R)**

   If a quantity which is specified in a region to define a field is a vector then the corresponding field is called vector field.

3. **Define scaling of a vector? (R)**

   This is nothing but, multiplication of a scalar with a vector. Such a multiplication changes the magnitude of a vector but not the direction.

4. **Define divergence? (R)**

   Divergence is defined as the net outward flow of the flux per unit volume over a closed incremental surface.

5. **State Divergence Theorem. (R)**

   The integral of the normal component of any vector field over a closed surface is equal to the integral of the divergence of this vector field throughout the volume enclosed that closed surface.

6. **What is physical significance of curl of a vector field? (R)**

   Curl gives rate of rotation. Curl F gives work done per unit area.

7. **What is physical significance of divergence? (R)**

   Divergence of current density gives net outflow of current per unit volume. Divergence of flux density gives net outflow per unit volume. In general, divergence of any field density gives net outflow of that field per unit volume.

8. State the conditions for a field to be a) solenoid b) irrotational. (R)

a) Divergence of the field has to be zero.

b) Curl of the field has to be zero.

9. Define scalar and vector quantity? (R)

- The scalar is a quantity whose value may be represented by a single real number which may be positive or negative. e.g, temperature, mass, volume, density.
- A quantity which has both a magnitude and a specified direction in space is called a vector.

e.g. force, velocity, displacement, acceleration.

10. What is a unit vector? What is its function while representing a vector? (R)

A unit vector has a function to indicate the direction. Its magnitude is always unity, irrespective of the direction which it indicates and the coordinate system under consideration.

11. Name 3 coordinate systems used in electromagnetic engineering? (R)

1) Cartesian or rectangular coordinate system.
2) Cylindrical coordinate system.
3) Spherical coordinate system.

12. How to represent a point in a Cartesian system? (R)

- A point in rectangular coordinate system is located by three coordinates namely x, y and z coordinates.
- The point can be reached by moving from origin, the distance x in x direction then the distance y in y direction and finally z in z direction.

13. Show how a point p represented in a spherical coordinate system. (R)

The point p can be defined as the intersection of three surfaces in spherical coordinate System.

r - Constant which is a sphere with centre as origin

0- Constant which is a right circular cone with apex as origin and axis as z axis.

z- Constant is a plane perpendicular to xy plane.

14. What are the types of integral related to electromagnetic theory? (R)

1. Line integral

2. Surface integral

3. Volume integral

15. Give the types of charge distribution. (R)

1. Line charge
2. Point charge
3. Surface charge
4. Volume charge.

16. Define volume charge density? (R)

Consider a charge distributed uniformly over a volume. If a differential charge element dQ is present in the differential volume element dv, then the volume charge density is defined as

p_v = dQ

= dV c/m

17. State stokes theorem. (R)

The line integral of a vector around a closed path is equal to the surface integral of the normal component of its curl over any surface bounded by the path.

18. Define electric field intensity. (R)

a. Electric field intensity is defined as the electric force per unit positive
b. charge. E=F/Q
c. =Q/4πεια V/m

19. Define electric scalar potential. (R)

- Potential at any point is defined as the work done in moving a unit positive charge from infinity to that point in an electric field.
- V=Q / 4

20. State coulombs law. (R)

Coulombs law states that the force between any two point charges is directly proportional to the product of their magnitudes and inversely proportional to the square of the distance between them. It is directed along the line joining the two charges.

21. Show that the two vectors A-6ax+ay-5az and B= 3(ax-ay+az) are perpendicular to each other. (R)

A.B = 6x3+1x(-3)+(-5)x(-3)

i. = 18-3-15

ii. = 0

AxB = 0

22. What are the conditions for two vectors A and B to be a parallel and Perpendicular. (U)

- For parallel
- For perpendicular
- A.B-0

23. State coulombs law. (R)

- Coulomb stated that the force between two very small charged objects separated by a large distance compared to their size is proportional to the charge on each object and inversely proportional to the square of the distance between them
- F (Q1 Q2)/r2

24. State gauss's law. (R)

- The electric flux passing through any closed surface is equal to the total charge enclosed by that surface

25. Define dipole and dipole moment. (R)

- Dipole or electric dipole is nothing but two equal and opposite point charges are separated by a very small distance. The product of electric charge and distance is known as dipole moment. It is denoted by m where Q is the charge and I is the length

26. What is point charge? (R)

- Point charge is one whose maximum dimension is very small in comparison with any other length

27. Name few applications of gauss law in electrostatics. (U)

- Gauss law is applied to determine the electric field intensity from a closed surface
- e.x: electric field can be determined for shell, two concentric shell or cylinders,etc

28. Define current density. (R)

- Current density is defined as current per unit area. It is denoted by J-I/A amp/m²

<u>PART B</u>

1. **(**a) State and prove divergence theorem. **(R) (7)**

(b) What are the major sources of electromagnetic fields? **(R) (6)**

2. Check validity of the divergence theorem considering the field D-2xy ax+x²ay c/m² and the rectangular parallelepiped formed by the planes x=0,x=1,y=0,y=2 & z=0,z-3.

(U) (13)

3. A vector field D = [5r2/4] Ir is given in spherical co-ordinates. Evaluate both sides of divergence theorem for the volume enclosed between r=1& r-2. **(U) (13)**
4. Explain three co-ordinate systems. **(U) (13)**
5. State and prove Gauss law and explain applications of Gauss law. **(R) (13)**
6. Derive an expression for the electric field due to a straight and infinite uniformly charged wire of length 'L' meters and with a charge density of a point P which lies along the perpendicular bisector of wire. **(U) (13)**
7. A circular disc of radius 'a' m is charged uniformly with a charge density. find the electric field at a point 'h' m from the disc along its axis. **(E) (13)**
8. Define the potential difference and absolute potential. Give the relation between potential and field intensity. **(R) (13)**
9. Derive an expression for potential due to infinite uniformly charged line and also derive potential due to electric dipole. **(U) (13)**
10. What is electromagnetics? Give detailed explanation on Electromagnetic model with corresponding units and constants. **(R) (13)**
11. (i) Verify whether the vector field E= yz âx + xz ây + xy â, is both solenoidal and irrotational. **(R) (7)**

    (ii) Given A-5âx and B-4 ây + tây. Find t such that angle between A and B is 45°.**(R) (6)**
12. (i) Write short notes on scalar and vector field. **(R) (6)**

    (ii) What is unit vector? Discuss on the mathematical operations with Vectors. **(R) (6)**
13. Explain how a spherical coordinate system describes the position of the point in free space and its differential elements. **(R) (13)**
14. (i) Summarize about the Dot product and cross product of vectors. State its properties and applications. **(U) (6)**

    (ii) The three fields are given by A 2â â B2âxây+2â, and C=2x-3ây +âz. Find the scalar and vector triple product. **(U) (7)**
15. Obtain the expressions for differential area and volume element in cylindrical coordinate system. **(U) (7)**
16. Analyze the geometrical position of the point in Cartesian coordinate system and obtain distance vector and differential elements. **(AZ) (13)**
17. Asses the spherical coordinates of A and Cartesian coordinates of B for the two given

points A(x 2, y=1, z=3) and B(p=1, q=45°, z=2) **(A) (13)**

18. Given the two points A (x2, y=3, z=-1) and B (r-4, 0-25°, ϕ-120°).

19. Solve the spherical coordinates of A and Cartesian coordinates of B. **(13) (A)**

20. State and prove divergence theorem for a given differential volume element. **(U) (13)**

21. Verify divergence theorem for the vector A=4x âx-2y²ây +z² az taken over the cube bounded between x=0,x=1, y=0,y=1 and z=0, z=1. **(AZ) (13)**

22. (i) Explain in detail line, surface and volume integral of vector function. **(AZ) (6)**

(ii) Express the rate of change of a scalar in a given direction in terms of its gradient and its properties.**(AZ) (7)**

23. (i) Verify the null identities using general orthogonal coordinates.**(E) (7)**

(ii) How do you explain the use of Helmholtz's theorem in electromagnetic engineering? **(E) (6)**

<u>PART C</u>

1. Evaluate divergence theorem for the given D= 2r z2 âr + r cos2φ âz , where r =3 and z=5. **(E) (15)**

2. Express vector B in Cartesian and cylindrical systems .Given B= 10/r âr + r cosθ âθ + âφ , Then find B at (-3,4,0) and (5,π/2,-2).**(E) (13)**

3. Validate stokes theorem for a vector field A = 2r cosφ $a\overline{r}$ + r âφ in cylindrical coordinates for the contour shown in figure below**. (C) (15)**

4. Estimate ∬F.nds using divergence theorem where F= 2 xy âx +y2 ây + 4 yz âz ,surface of the cube bounded by x=0,x=1, y=0 ,y=1 and z=0, z=1**. (C) (15)**

UNIT II

ELECTROSTATICS

PART A

1. **Define point charge. (R)**

   A point charge means that electric charge which is separated on a surface or space whose geometrical dimensions are very small compared to other dimensions, in which the effect of electric field to be studied.

2. **Define one coulomb. (R)**

   One coulomb of charge is defined as the charge possessed by (1/1.602x109) i.e $6x10^{18}$ number of electrons.

3. **What are the various types of charge distribution? Give an example for each. (R)**
   - Point charge - Ex. Positive charge
   - Line charge - Ex. A sharp beam in a cathode ray tube.
   - Surface charge - Ex. The plate of a charged parallel plate capacitor.
   - Volume charge - Ex. The charged cloud.

4. **State the assumptions made while defining a Coulomb's law. (R)**
   - The two charges are stationary.
   - The two charges are point charge.

5. **What is an equipotential surface? (R)**

   An equipotential surface is an imaginary surface in an electric field of a given charge distribution, in which all points on the surface are at the same electric potential.

6. **What is an electric flux? (R)**

   The total number of lines of force in any particular electric field is called electric flux. It is represented by the symbol ø. Similar to the charge, unit of electric flux is also Coulomb.

7. **Define electric flux density. (R)**

   The net flux passing normal through the unit surface area is called electric flux density. It is denoted as D. It has a specified direction which is normal to the surface area under consideration hence it is a vector field.

8. **State Gauss's Law. (R)**

   The electric flux passing through any closed surface is equal to the total charge enclosed by that surface.

9. State the application of Gauss's law. (R)

1) The Gauss's law can be used to find E and D for symmetrical charge distributions.

2) It is used to find the charge enclosed or the flux passing through the closed surface.

10. What is an equipotential surface? (R)

An equipotential surface is an imaginary surface in an electric field of a given charge distribution, in which all points on the surface are at the same electric potential.

11. Define the unit of Potential difference. (R)

The unit of potential difference is Volt. One Volt potential difference is one Joule of work done in moving unit charge from one point to other in the field.

12. Define potential difference. (R)

The work done per unit charge in moving unit charge from B to A in the field E is called potential difference between the points B to A.

13. Define relaxation time. (R)

The relaxation time ô is defined as the time required by the charge density to decay to 36.8% of its initial value.

14. What is Potential Gradient? (R)

The rate of change of potential with respect to the distance is called potential gradient

15. What is Gaussian surface? What are the conditions to be satisfied in special Gaussian surface? (R)

The surface over which is the Gauss's law is applied is called Gaussian surface. Obviously such a surface is a closed surface and it has to satisfy the following conditions.

1) The surface may be irregular but should be sufficiently large so as to enclose the entire charge.

2) The surface must be closed.

3) At each point of the surface D is either normal or tangential to the surface.

4) The electric flux density D is constant over the surface at which D is normal.

16. What is Gradient of V? (R)

The maximum value of rate of change of potential with distance dv/dL is called gradient of V

17. Define Absolute potential. (R)

The work done in moving a unit charge from infinity (or from reference point at which potential is zero) to the point under the consideration against E is called absolute potential of that point.

18. What is Polarization? (R)

The applied field E shifts the charges inside the dielectric to induce the electric dipoles. This process is called Polarization.

19. What is Polarization of Dielectrics? (R)

Polarization of dielectric means, when an electron cloud has a centre separated from the nucleus. This forms an electric dipole. The dipole gets aligned with the applied field.

20. State Biot-Savarts law. (R)

It states that the magnetic flux density at any point due to current element is proportional to the current element and sine of the angle between the elemental length and inversely proportional to the square of the distance between them dB sine/4mr.

21. Write Lorentz force equation & mention its applications. (R)

Lorentz force equation is given by

F=ma

N=Q(E + V X

Applications :

a) Used to determine electron or bits in magnetron.

b) Used to determine the proton path in cyclotron.

22. Mention the importance of Lorentz force equation. (U)

Lorentz force equation realtes mechanical force to the electric force. Lorentz force equation is given by

F=ma

=Q(E + V X B)N

23. What is lorentz force equation? (R)

Lorentz force is the force experienced by the test charge .It is maximum if the direction of movement of charge is perpendicular to the orientation of field lines.

Lorentz force equation is given by

F=ma Q(E + V X B)N

24. Brief about ampere circuital law in integral form. (R)

The line integral of the magnetic field intensity around a closed path is equal to the sum of the currents flowing through the area enclosed by the path.

25. Brief about complex pointing vector. (U)

complex pointing vector P is Sav (r)=2 Re[EXH]

26. Compare diamagnetic, paramagnetic and ferromagnetic materials (U)

- Diamagnetic: in diamagnetic materials magnetization is opposed to the applied field.
- It has weak magnetic field Paramagnetic field: in paramagnetic materials magnetization is in the same direction as the field. It has weak magnetic field
- Ferromagnetic: in ferromagnetic materials magnetization is in the same direction as the field. It has strong magnetic field

27. Write down the magnetic boundary conditions. (R)

The normal components of flux density B is continuous across the boundary The tangential component of field intensity H is continuous across the boundry.

28. Give the force on a current element. (R)

The force on a current element Idl is given by

dF=IxBdl

sin = BI dl

29. Define magnetic dipole. (R)

A small bar magnet with pole strength Qm and length I may be treated as magnetic dipole whose magnetic moment is Qm 1

30. Define hysteresis. (R)

- The phenomenon which causes magnetic flux density to lag behind magnetic field intensity so that the magnetization curve for increasing and decreasing applied fields is not the same, is called hysteresis.
- It is used to find the field due to current J

31. Define magnetic dipole moment(R)

- A bar magnet of pole strength Qm and length L. constitutes a magnetic dipole of magnetic dipole moment Qm L
- Magnetic dipole moment m = Qm L(A.m^2)

32. Define magnetic moment. (R)

- Magnetic moment is defined as the maximum torque per magnetic induction (flux density) m-IA

PART B

1. Derive the boundary conditions of the normal and tangential components of electric field at the interface of two media with different dielectrics. **(U) (13)**
2. Derive an expression for the capacitance of a parallel plate capacitor having two dielectric media. **(U) (13)**
3. Prove Laplace's and Poisson's equations. **(U) (13)**
4. Derive an expression for the capacitance of two wire transmission line. **(U) (13)**
5. Briefly explain about the application of Poisson's and Laplace's equations. **(U) (13)**
6. Derive the expression for co-efficient of coupling. **(U) (13)**
7. Briefly explain about the wave incident **(U)**
   (i) Normally on perfect conductor **(7)**
   (ii) Obliquely to the surface of perfect conductor. **(6)**
8. Q1 and Q2 are the point charges located at (0,-4, 3) and (0, 1, 1).If Q1 is 2 nC, Find Q2 such that the force on test charge at (0,-3, 4) has no z component. **(E) (13)**
9. (i) State and explain coulomb's law and deduce the vector form of force equation between the two point charges. **(R) (7)**
   (ii) Write note on principle of Superposition as applied to charge distribution. **(R) (6)**
10. Obtain the formula for the electric field intensity of an infinite long straight line carrying uniform line charge density of ρL.**(AZ) (13)**
11. (i) State and prove Gauss law. **(R) (6)**
    (ii) Obtain the point form of gauss law. **(R) (7)**
12. Explain about any two applications of Gauss law with neat diagrams.**(U) (13)**
13. Derive the expression for potential due to an electric dipole at any point P. Also find the electric field intensity and in terms of dipole moment. **(U) (13)**
14. (i) Analyze about nature of dielectric material and polarization. **(AZ) (7)**
    (ii) Determine the value of polarization and electric field intensity of homogeneous slab of lossless dielectric with electric susceptibility of 0.12 and electric flux density of 1.6nC/m2. **(AZ) (6)**
15. Explain the importance of Poisson's electromagnetics with necessary equations and Laplace's equation in electromagnetics with necessary equation.**(U) (13)**
16. Derive the boundary conditions of the normal and tangential components of electric field at the interface of two media with different dielectrics. **(U) (13)**

17. Formulate the expression for electrostatic energy required to assemble a group of charges at rest.**(A) (13)**

18. Derive the boundary conditions between conductor and dielectrics from the boundary conditions between conductor and free space **(U) (13)**

19. (i) Write the equation of continuity in integral and differential form **(R) .(7)**

    (ii) Discuss the point form of ohm's law and obtain the expression for resistance of a conductor. **(R) (6)**

20. A cylindrical capacitor consists of an inner conductor of radius 'a' & an outer conductor whose inner radius is 'b'. The space between the conductors is filled with a dielectric permittivity ε_r & length of the capacitor is L. Estimate the value of the Capacitance.**(R) (13)**

21. Evaluate the expression for a parallel plate capacitor. Also derive the equation for composite parallel plate capacitor with dielectric boundary parallel and normal to the plates. **(E) (13)**

Part C

1. Determine the expression for the electric field due to a charge circular ring of radius r placed in xy plane with center at origin having charge density of ρ_L C/m. Find E at the point (0, 0, 5) m from the circular ring of charge with radius 5 m lying in z = 0 plane with center at origin and having ρ_L = 10 nC/m. **(E) (15)**

2. (i) Derive the equation of potential due to point, line, and surface and volume charge and obtain the relation between E and V**. (E) (8)**

   (ii) Given the potential $V= (10 \sin\theta \cos\varphi)/r^2$. Find the electric flux density at (2, π/2, 0).**(E) (7)**

3. Obtain at point P the magnitudes of V, E, E_t, E_N, D, D_N and ρ_S of a potential field $V= 100 e^{-5x} \sin 3y \cos 4z$ volts. Let point P (0.1, π/12, π/24) be located at a conductor free space boundary**. (A) (15)**

4. (i) Determine the capacitance of general spherical capacitor, isolated sphere coated with dielectric**.(AZ) (10)**

   (ii) For a conducting sphere of 2 cm in diameter, covered with a layer of polyethylene with ε_r = 2.26 and 3 cm thick, find the capacitance **.(E) (5)**

UNIT III

MAGNETOSTATICS

1. **What are the significant physical differences between Poisson 's and laplace 's equations. (R)**
   - Poisson 's and laplace 's equations are useful for determining the electrostatic potential V in regions whose boundaries are known. When the region of interest contains charges poissons equation can be used to find the potential.
   - When the region is free from charge laplace equation is used to find the potential.

2. **Brief about boundary conditions for electric fields. (R)**

   i) The tangential component of the electric field is continuous at the surface. Etl = Et2

   ii) The normal component of the electric flux density is continuous if there is no surface charge density.

$$D_{n1} = D_{n2}$$

3. **Define dielectric strength. (R)**
   - The dielectric strength of a dielectric is defined as the maximum value of electric field that can b applied to the dielectric without its electric breakdown.

4. **What do you meant by magnetization? (R)**

   Magnetization can be defined according to the following equation:

$$M = N$$

$$m = nm$$

   Here, M represents magnetization; m is the vector that defines the magnetic moment; V represents volume; and N is the number of magnetic moments in the sample. The quantity N/V is usually written as 7, the number density of magnetic moments.

5. **What is meant by dielectric breakdown? (R)**

   When the electric field in a dielectric is sufficiently large, it begins to pull electrons completely out of the molecules & the dielectric becomes conducting.

6. **What is a homogenous material ? (R)**

   Homogenous material is one for which the quantities permeability, permittivity are constant throughout the medium.

7. **Name the magnetic materials. Diamagnetic. (R)**
   - Paramagnetic
   - Ferromagnetic
   - Ferrimagnetic.

8. **Derive the expression for capacitance between two parallel plates. (U)**

$$C=eA/d$$

9. What is lorentz force? (R)

Lorentz force is the force experienced by the test charge. It is maximum if the direction of movement of charge is perpendicular to the orientation of field lines.

F=Q1Q2/4πεr ar

10 . What is Magnetic Field? (R)

The region around a magnet within which influence of the magnet can be experienced is called Magnetic Field.

11. What are Magnetic Lines of Force? (R)

- The existence of Magnetic Field can be experienced with the help of compass field. Such a field is represented by imaginary lines around the magnet which are called Magnetic Lines of Force.

12. State Stoke's Theorem. (R)

- The line integral of F around a closed path L is equal to the integral of curl of
- F over the open surface S enclosed by the closed path L.

13. Define scalar magnetic Potential. (R)

- The scalar magnetic potential Vm can be defined for source free region where Ji.e. current density is zero.

14. What is the fundamental difference between static electric and magnetic field lines? (R)

- There is a fundamental difference between static electric and magnetic field lines. The tubes of electric flux originate and terminate on charges, whereas magnetic flux tubes are continuous.

15. State Kirchoff's Flux law. (R)

- It states that the total magnetic flux arriving at any junction in a magnetic circuit is equal to the magnetic flux leaving that junction. Using this law, parallel magnetic circuits can be easily analyzed.

16. State Kirchoff's MMF law. (R)

- Kirchoff's MMF law states that the resultant MMF around a closed magnetic circuit is equal to the algebraic sum of products of flux and reluctance of each part of the closed circuit.

17. What is Magnetization? (R)

- The field produced due to the movement of bound charges is called Magnetization represented by M.

18. State Biot Savart Law. (R)

- The Biot Savart law states that, the magnetic field intensity dH produced at a point p due to a differential current element IdL is,

- Proportional to the product of the current I and differential length dL.
- The sine of the angle between the element and the line joining point p to the element and
- Inversely proportional to the square of the distance R between point p and the element.
- dH œ Idl sine/R2

19. Describe what are the sources of electric field and magnetic field? (U)

- Stationary charges produce electric field that are constant in time, hence the term
- electrostatics. Moving charges produce magnetic fields hence the term magnetostatics.

20. Define Magnetic flux density. (R)

- The total magnetic lines of force i.e. magnetic flux crossing a unit area in a plane at right angles to the direction of flux is called magnetic flux density. Unit is Wb/m^2.

21. State Ampere's circuital law. (R)

- The line integral of magnetic field intensity H around a closed path is exactly equal to the direct current enclosed by that path.

22. Define Magnetic field Intensity. (R)

- Magnetic Field intensity at any point in the magnetic field is defined as the force experienced by a unit north pole of one Weber strength, when placed at that point. Unit is N/Wb.

23. What is rotational and irrotational vector field? (R)

- If curl of a vector field exists then the field is called rotational. For irrotational vector field, the curl vanishes i.e. curl is zero.

24. Give the application of Stoke's theorem. (R)

- The Stoke's theorem is applicable for the open surface enclosed by the given closed path.
- Any volume is a closed surface and hence application of Stoke's theorem to a closed surface which enclosed certain volume produces zero answer.

PART B

1. Derive the expression for magnetic field intensity and magnetic flux density due to finite and infinite line. **(U) (13)**
2. Derive the expressions for magnetic field intensity and magnetic flux density due to circular coil. **(U) (13)**

3. Derive an expression for force between two current carrying conductors. **(U) (13)**
4. State Ampere's circuital law and explain any two applications of Ampere's circuital law. **(R) (13)**
5. Derive the expression for the magnetic field intensity due to rectangular coil carrying
6. current I in a uniform field. Deduce the equation to find the H due to square coil. **(U) (13)**
7. State Ampere's circuital law and prove the same. **(R) (13)**
8. Find the magnetic field intensity at the centre O of a square loop of sides equal to 5M and carrying 10A of current. **(E) (13)**
9. An iron ring with a cross sectional area of 3cm square and mean circumference of 15 cm is wound with 250 turns wire carrying a current of 0.3A. The relative permeability of ring is 1500. Calculate the flux established in the ring. **(E) (13)**
10. From the Biot-Savart's law, write the expression for magnetic field intensity at a point P and distance R from the infinitely long straight current carrying conductor. **(R) (13)**
11. Derive the equations for magnetic field intensity and magnetic flux density at the center of the square current loop using Biot-Savart's law.**(R) (13)**
12. Write short notes on
    (i) Magnetic field due to current carrying conductors. **(R) (7)**
    (ii) Law of non-magnetic monopoles. **(R) (6)**
13. State about magnetization? Describe the classification of magnetic materials with examples. **(R) (13)**
14. Determine the magnetic field intensity at the origin due to current element Idl = 3π (âx + 2 ây + 3âz) μA · m at (3,4,5)m in free space. **(E) (13)**
15. (i) Discuss about the force on a straight and long current carrying conductor placed in the uniform magnetic field. **(U) (7)**
    (ii) Illustrate with diagram magnetic torque. **(U) (6)**
16. (i) Using Biot-Savart's law, illustrate the magnetic field intensity on the axis of a circular loop of radius R carrying a steady current I. **(U) (7)**
    (ii) A circular loop located on x2 + y2 = 9, z = 0 carries a direct current of 10 A along aφ. Calculate H at (0, 0, 4) and (0, 0,-4). **(U) (6)**
17. Derive the expression for Ampere circuital law. Apply the law for any two applications with necessary illustrations.**(U) (13)**

18. (i) Derive the Maxwell's curl equation for magnetic field from Ampere circuital law. **(A) (7)**

(ii) Solve the magnetic field at a point P(0.01, 0, 0)m if current through a co- axial cable is 6A. which is along the z-axis and a=3mm, b=9mm, c=11mm. **(A) (6)**

19. Let A=(3y-z)ax+2xzay Wb/m in a region of free space.

(i) Prove that ∇.V = 0 **(AZ) (5)**

(ii) At P(2,-1,3) find A, B, H and J **(AZ) (8)**

20. (i) Estimate the expression for inductance of a toroidal coil carrying current I, with N turns and the radius of toroid 'r'. **(E) (6)**

(ii) Formulate the expression for inductance of a coaxial cable. **(A) (7)**

21. Examine the magnetic field intensity within a magnetic material where

(i) M=150A/m and μ=1.5x10-5 H/m **(E) (7)**

(ii) B=300μT and χm=15. **(E) (6)**

22. Describe about the magnetic boundary condition at the interface between two magnetic medium and derive the necessary boundary conditions. **(U) (13)**

23. A solenoid with N1=2000, r1=2 cm and l1= 100cm is concentric within a second coil of N2= 4000, r2= 4cm and l2=100cm.Calculate mutual inductance assuming free space conditions.**(AZ) (13)**

PART C.

24. (i) Distinguish magnetic scalar potential from the vector potential with necessary equations. **(U) (8)**

(ii) Calculate the magnetic flux density for a current distribution in free space, A= (2x2y+yz) âx + (xy2-xz3) ây-(6xyz-2x2y2) âz Wb/m. **(E) (7)**

25. (i) At a point P(x, y, z) the components of vector magnetic potential $\vec{A}$ are given as Az = (4x + 3y+2z), Ay = (5x +6y +3z) and Az = (2x+3y+5z). Invent $\vec{B}$ at point P. **(E) (8)**

(ii) A solenoid has an inductance of 20mH. If the length of the solenoid is increased by two times and the radius is decreased to half of its original value, Compute the new inductance.**(7) (E)**

26. Region 1 is the semi-infinite space in which 2x-5y>0, while region 2 is defined by 2x-5y<0. Let μr1=3, μr2=4 and $\bar{H}$ 1=30$\bar{a}$ x A/m. Calculate

(a) |$\bar{B}$ 1|, (b) |$\bar{B}$ N1|, (c) |$\bar{H}$ tan1|, (d) |$\bar{H}$ 2|. **(E) (15)**

(i) A solenoid is 50 cm long, 2 cm in diameter and contains 1500 turns. The cylindrical core has a diameter of 2 cm and a relative permeability of 75. This coil is co-axial with second solenoid which is 50 cm long, 3 cm diameter and 1200 turns. Solve the inductance L for inner and outer solenoid. **(R) (8)**

(ii) Propose the solution for energy stored in the solenoid having 2m long and 10 cm in diameter and is wound with 4000 turns of wire, carrying a current of 8 A. **(R) (7)**

UNIT IV

TIME-VARYING FIELDS AND MAXWELL's EQUATIONS

PART A

1. **What is skin effect? (R)**

   In good conductors, the wave attenuates very rapidly & the fields are confined to the region near the surface of the conductor. This phenomenon is called the skin effect.

2. **Define Brewster angle. (R)**
   - Brewster's angle is the angle at which the reflected light is linearly polarized normal to the plane incidence. At the end of the plasma tube, light can leave through a particular angle
   - (Brewster's angle) and essentially be highly polarized. Maximum polarization occurs when the angle between reflected and transmitted light is 90° thus Ør+0=90°; since sin (90-x) = cos x
   - Snell's provides (sin Ø/cos Ø)=n2/n1:Ør is Brewster's angle = tan -(n2/n1)

3. **Define skin depth. (R)**

   It is defined as that depth in which the wave has been attenuated to 1/e or approximately 37% of its original value.

4. **Define a wave. (R)**
   - If a physical phenomenon that occurs at one place at a given time is reproduced at other places at later times, the time delay being proportional to the space separation from the first location then the group of phenomena constitutes a wave.

5. **Mention the properties of uniform plane wave. (U)**
   - At every point in space, the electric field E and magnetic field H are perpendicular to each other.
   - The fields vary harmonically with time and at the same frequency everywhere in space.

6. **Define intrinsic impedance or characteristic impedance. (R)**

   It is the ratio of electric field to magnetic field or it is the ratio of square root of permeability to permittivity of medium.

7. **Define skin depth. (R)**

   It is defined as that depth in which the wave has been attenuated to 1/e or approximately 37% of its original value.

6. Define Poynting vector. (R)

The pointing vector is defined as rate of flow of energy of a wave as it propagates.

P=EX H

7. State Poynting Theorem. (R)

The net power flowing out of a given volume is equal to the time rate of decrease of the energy stored within the volume conduction losses.

8. Explain the steps in finite element method. (U)

- Discrimination of the solution region into elements.
- Generation of equations for fields at each element.
- Assembly of all elements.
- Solution of the resulting system.

10. State Maxwell's fourth equation. (R)

The net magnetic flux emerging through any closed surface is zero.

11. State Maxwell's Third equation. (R)

The total electric displacement through the surface enclosing a volume is equal to the total charge within the volume.

12. State the principle of superposition of fields. (R)

The total electric field at a point is the algebraic sum of the individual electric field at that point.

13. Define loss tangent. (R)

Loss tangent is the ratio of the magnitude of conduction current density to displacement current density of the medium.

14. Define reflection coefficient. (R)

Reflection coefficient is defined as the ratio of the magnitude of the reflected field to that of the incident field.

15. Define transmission coefficient. (R)

Transmission coefficient is defined as the ratio of the magnitude of the transmitted field to that of incident field.

16. What will happen when the wave is incident obliquely over dielectric – dielectric boundary? (R)

When a plane wave is incident obliquely on the surface of a perfect dielectric part of the energy is transmitted and part of it is reflected But in this case the transmitted wave will be refracted, that is the direction of propagation is altered.

17. What are uniform plane waves? (R)

Electromagnetic waves which consist of electric and magnetic fields that are perpendicular to each other and to the direction of propagation and are uniform in plane perpendicular to the direction of propagation are known as uniform plane waves.

18. What is the significant feature of wave propagation in an imperfect dielectric? (R)

The only significant feature of wave propagation in an imperfect dielectric compared to that in a perfect dielectric is the attenuation undergone by the wave.

19. What is the major drawback of finite difference method? (R)

The major drawback of finite difference method is its inability to handle curved boundaries accurately.

20. Define power density. (R)

The power density is defined as the ratio of power to unit area. Power density power/unit area.

21. What is Normal Incidence? (R)

When a uniform plane wave incidences normally to the boundary between the (NP/m). But practically it is expressed in decibel (dB).

23. What is phase constant? (R)

When a wave propagates, phase change also takes place. Such a phase change is expressed by a phase constant å. It is measured in radian per meter (rad/m).

24. How voltage maxima and minima are separated? (AZ)

In general voltage minima are separated by one half wavelength. Also the voltage maxima are also separated by one half wave length.

PART B

1. With necessary explanation, derive the Maxwell's equation in differential and integral forms. **(U) (13)**
2. Write short notes on faradays law of electromagnetic induction. **(R) (13)**
3. The magnetic field intensity in free space is given as H-Hosine yt A/m. Where = ut-âz and â is a constant quantity. Determine the displacement current density. **(E) (13)**
4. (a) What is the physical significance of the poynting vector? **(R) (13)**

   (b) State and explain the poynting theorem. **(R) (13)**
5. Derive the general wave equation. **(U) (13)**
6. Derive an expression for energy stored and energy density in an Electrostatic field. **(U) (13)**
7. Derive a wave equation for non dissipative medium making use of Maxwell equations and field vectors E and H. **(U) (13)**
8. Define wave. Derive the free space electromagnetic wave equation. **(R) (13)**
9. (i) Electric flux density in a charge free region is given by $D=10xax+5yay+kzaz\mu C/m2$. Find the constant k. **(R) (6)**

(ii) If the magnetic field H= (3xcosβ+6ysinα) az, Find current density J if fields are invariant with time. **(R) (7)**

10. A circular loop of N turns of conducting wire lies in the XY plane with its center at the origin of magnetic field specified by B= B0 Cos (πr/2b) * Sin ωt az where, b is the radius of the loop and ω is the angular frequency. Find the emf induced in the loop.**(R) (13)**

11. (i) Express Maxwell's equation for harmonically varying fields.**(R) (7)**

(ii) In a given lossy dielectric medium, conduction current density Jc=0.02 sin109t (A/m2). Find the displacement current density if σ=103 S/m and εr=6.5**(R) (6)**

12. Derive the Maxwell's equation for a time varying are modified for time varying from fundamental laws of electric and magnetic fields.**(R) (13)**

13. Write in detail on retarded scalar and vector potential and derive the generalized wave equation. In free space.**(R) (13)**

14. Illustrate the integral and point form of Maxwell's equations for static fields**(U) (13)**

15. (i) Express the transformer EMF induced in a stationary closed path in a time varying B field.**(U) (7)**

(ii) Obtain the motional EMF induced in moving closed path in static B field**(U) (6)**

16. Calculate the maximum emf induced in a coil of 4000 turns of radius of 12 cm rotating at 30rps in a magnetic field of 0.05 Wb/m2. **(E) (13)**

17. (i) Demonstrate the detailed steps for the derivation of electromagnetic boundary conditions for a time varying fields. **(A) (7)**

(ii) Determine emf induced about the path r = 0.5, z = 0, t = 0. If B = 0.01sin377t **(A) (6)**

18. (i) Illustrate with necessary fundamentals the equation of continuity of current in differential form.**(A) (7)**

(ii) Prove that modified ampere's law is consistent with the time varying field. **(A) (6)**

19. Give the physical interpretation of Maxwell's first and second equations. **(U) (13)**

20. In a region where Ɛr = μr =1 and σ=0 let A=10-3 y cos3*108 t cosz az Wb/m and V=3*105 y sin 3*108 t sinz V. Find E and H.**(E) (13)**

21. Derive an expression for displacement current density an the physical significance of it.**(U) (13)**

22. Do the fields E=Em sinx sint ay and H=(Hm //μ0) cosx cost az satisfy Maxwell's equations?**(R) (13)**

PART C

1. In a material for which σ=5S/m and Ɛr = 1, the electric field intensity is E= 250 sin1010t V/m. Estimate the conduction and displacement current densities, and the frequency at which both have equal magnitudes.**(E) (15)**
2. The unit vector 0.48 âx – 0.6 ây + 0.64 âz is directed from region 2 (Ɛr2 = 2.5, μr2 =2, σ2 = 0) towards region 1 (Ɛr1 = 4, μr1 =10, σ1 = 0). If H1= (-100 âx – 50 ây + 200 âz) sin 400t A/m at the point p in region 1 adjacent to the boundary. Determine the amplitude at point P of HN1, Htan1, HN2, H2.**(E) (15)**
3. Calculate β and H in a medium characterized by σ=0, μ= μ0, Ɛ=4 Ɛ0 and E=20 sin (108t-βz)ay V/m.**(E) (15)**
4. Solve the value of k such that following pairs of field satisfies Maxwell's equation in the region where σ=0, σv=0

(i) $\bar{E}$ =[kx-100t] $\bar{a}$ y V/m, $\bar{H}$ =[x+20t] $\bar{a}$ z A/m and μ=0.25H/m, ε=0.01F/m **(AZ) (8)**

(ii) $\bar{D}$ =5x$\bar{a}$ x-2$\bar{a}$ y+kz$\bar{a}$ z μC/m2, $\bar{B}$ =2$\bar{a}$ y mT and μ=μ0, ε=ε0. **(AZ) (7)**

UNIT 5

PLANE ELECTROMAGNETIC WAVES

PART A

1. Define phase velocity and group velocity. (R)

The velocity of entire group of waves as a whole is called group velocity denoted as Vg. The relation between vp and vg as

$V_g = d\omega / d\beta$ $V_P = -dV/d\lambda$

2. What is meant by Brewster's angle ? (R)

It is the angle of incidence at which there is no reflection. For parallel polarization, the Brewster angle is given by,

$$\theta_B = \tan^{-1}\sqrt{\in 2/\in 1}$$

3. What is uniform plane wave ? (R)

An EM wave propagating in Z-direction if its fields E and H are independent of x and y directions and mutually perpendicular to each other is called uniform plane wave.

4. Define propagation constant. (R)

The propagation constant is a complex quantity expressed interms of the properties of the medium. It is denoted by y and is given by, $\gamma = a + j\beta = \zeta\omega\mu\ (\sigma + í\omega\varepsilon)$.

5. What is meant by attenuation constant and phase constant ? (R)

- The real part of propagation constant is called attenuation constant. It is denoted by a It is measured in neper per meter (Np/m). It indicates the amount by which the amplitude of the signal reduces. The imaginary part of propagation constant is called phase constant.
- It is denoted by ß It is measured in radian per meter. It indicates the mount by which the phase change of the signal occurs

6. Define wavelength. (R)

A distance required to effect a phase change of 2n radian is called wavelength is denoted by and measured in meter. According to the fundamental definition, wavelength is given by,

$$\lambda = 2\Pi/\beta$$

7. Define Phase Velocity. (R)

The phase velocity of the uniform plane wave is defined as the velocity with which the phase of the wave propagates. It is denoted as Vp

$$V_p = 1/\sqrt{\mu\varepsilon_0}$$

8. Write down expressions for velocity, attenuation constant , Phase constant, Intrinsic impedance if the wave propagates in a perfect dielectric. (U)

$V = c/\sqrt{\mu_r\varepsilon_r}$

Attenuation constant = 0

$\beta = \omega\sqrt{\mu\varepsilon}$

$\eta = \eta_0\sqrt{\mu/\varepsilon}$

9. What is meant by perfect dielectric? (R)

If the medium is perfect dielectric , then its properties are given by $\sigma = 0$

$$\mu = \mu_r\mu_0 \text{ and } \varepsilon = \varepsilon_r\varepsilon_o$$

For the perfect dielectric as conductivity is zero, the medium is lossless medium

10. Explain skin effect. (U)

From the expression of the skin depth, it is clear that is inversely proportional to the square root of frequency .so for the frequencies in the microwave range, The skin depth is very small for good conductors.

11. What is standing wave ratio? (R)

The standing wave ratio is defined a sthe ratio of maximum to minimum amplitude of voltage

$$S = E1st\ max/E1s\ min$$

12. Mention the two properties of uniform plane wave. (U)

It is a functiom of time and space both.It shows an electri field and magnetic field vector both in same plane.It travels with high velocity.It radius outwards from source in all directions.In space at every point electric field and magnetic field are perpendicular to each other

13. State poynting vector. (R)

The pointing theorem is based on law of conservation of energy in electromagnetism.the pointing theorem states that the net power flowing out of a given volume is equal to a time rate of decrease in the energy stored within volumeminus the ohmic power dissipated.

14. Define skin depth. (R)

The distance through which the amplitudes of the travelling wave decrease to 37%

of the original amplitude is called skin depth

Skin depth $=1/\beta = 1/\sqrt{\Pi f \mu \sigma}$

15. Write the expressions for instantaneous and complex pointing vector. (U)

The instantaneous Poynting vector is given by

P = ExH

The complex pointing vector is given by

P = ½ Ex H

The average pointing vector is given by

Pavg = ½ Re{ExH]

16. Give typical examples of Electromagnetic waves. (R)

The typical examples of the electromagnetic waves are radio waves , light rays , radar beams, television signals etc.

17. What is meant by transverse Electromagnetic wave? (R)

If the fields E and H of an Electromagnetic wave are mutually Perpendicular to each other and if the direction of propagation of an electromagnetic wave is orthogonal to the plane consisting E and H field vectors then the wave is said to be transverse Electromagnetic waves

18. What is loss tangent? (R)

The term $\sigma/\omega\varepsilon$ is called loss tangent of dielectric and the angle θ is called loss angle.

19. What is the significance of loss tangent? (R)

- When $\sigma >> \omega\varepsilon$, the loss tangent is very high , thus a medium is said to be good conductors.
- When $\sigma << \omega\varepsilon$, the loss tangent is very small , thus a medium is said to be good dielectrics.

20. What is the electric field and power flow in the coaxial cable? (R)

The power is transferred along the coaxial cable to the load resistance R.

The total power flow along a cable is given by

$$W = VI$$

PART B

1. Starting from the Maxwell's equation derive homogenous vector Helmholtz's equation in phasor form. **(U) (13)**
2. Find the wave equation for the electric and magnetic fields for free space conditions. **(R) (13)**

3. Write short notes on uniform plane waves and derive the wave equation. **(U) (13)**

4. (i) State and prove Poynting theorem. **(R) (8)**

   (ii)Describe the Poynting vector, average power and instantaneous power. **(U) (5)**

5. A uniform plane wave Ey =10 sin (2π * 108 t – β x) ây is travelling in x directon in free space. Determine Phase constant, Phase velocity, Expression for Hz. Assume Ez = 0 = Hy. **(E) (13)**

6. Explain the condition under which the magnitude of the reflection coefficient equals that of the transmission coefficient for a uniform wave at normal incidence on an interface between two lossless dielectric medium. **(U) (13)**

7. Demonstrate the equations for a plane wave incident normally on a plane dielectric boundary. **(U) (13)**

8. A uniform plane wave in a lossless medium with intrinsic impedance Ƞ1 is incident normally onto another lossless medium with intrinsic impedance Ƞ2 through a plane boundary. Develop the expressions for the time average power densities. **(C) (13)**

9. In free space, E= 50 cos (ωt- βz) âx V/m. Solve for the average power crossing a circular area of radius 2.5 m in the plane Z=0. Assume Em = Hm Ƞ0 and Ƞ0 =120πΩ.**(R) (13)**

10. Determine and summarize the intrinsic impedance, wavelength, attenuation, phase and propagation constant for electromagnetic waves in any medium. **(U) (13)**

11. Derive the electromagnetic wave equation in phasor form with necessary equations. **(U) (13)**

12. Illustrate the power flow in a coaxial cable using Poynting theorem.**(AZ) (13)**

13. Examine the expressions for the transmission and reflection coefficients at the interface of two media for normal incidence. **(U) (13)**

14. Estimate the frequency of a wave and the conductivity of the medium for a uniform plane wave travelling at a velocity of 2.5*105 m/s having a wavelength of 0.25 mm in a non-magnetic good conductor. **(E) (13)**

PART – C

1. A 6580 MHz uniform plane is propagating in a material medium of Ɛr =2.25. If the amplitude of electric field intensity of a losseless medium is 500 V/m. Calculate the phase constant, Propagation constant, velocity , wavelength and intrinsic impedance. Also find the amplitude of magnetic field intensity. **(E) (15)**

2. (i) Determine α, β and the wavelength of a material for a 9 GHz wave propagating

through a material that has a dielectric constant of 2.4 and loss tangent of 0.005. **(E) (10)**

(ii) Calculate the skin depth for a medium with conductivity 100 ℧ $/m$, relative permeability of 2 and relative permittivity of 3A at 1 GHz. **(E) (5)**

3. Determine the amplitudes of reflected and transmitted fields (electric and magnetic both) at the interface of two regions, if Ei = 1.5 mV/m in region 1 for which Ɛr1 = 8.5, μr = 1 and σ =0 and region 2 is a free space. **(AZ) (15)**

4. (i) Calculate the skin depth and wave velocity at 2 MHz in aluminum with conductivity 40 MS/m and μr = 1. **(E) (10)**

(ii) A plane wave propagating in free space has a peak electric field of 750mV/m. Estimate the average power through a square area of 12cm on a side perpendicular to the direction of propagation. **(AZ) (5)**

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HoD Remarks: