EC6403 -ELECTROMAGNETIC FIELDS CLASS/SEM: II ECE/IV SEM

UNIT I - STATIC ELECTRIC FIELD

Part A - Two Marks

1. Define scalar field?

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?

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?

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. What are co-planar vector?

The vectors which lie in the same plane are called co-planar vectors.

5. Define base vectors?

The base vectors are the unit vectors which are strictly oriented along the directions of the coordinate axes of the given coordinate system.

6. What is a position vector?

Consider a point $p(x, y, z)$ are Cartesian coordinate system. Then the position vector of point p is represented by the distance of point p from the origin directed from origin to point. This is also called as radius vector.

7. Define Divergence.

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

8. State Divergence Theorem.

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.

9. What is physical significance of curl of a vector field?

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

10. What is physical significance of divergence?

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.

11. State the conditions for a field to be a) solenoidal b) irrotational.

a) Divergence of the field has to be zero.

b) Curl of the field has to be zero.

12. Define scalar and vector quantity?

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.

13. What is a unit vector? What is its function while representing a vector?

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.

14. Name 3 coordinate systems used in electromagnetic engineering?

1) Cartesian or rectangular coordinate system.

2) Cylindrical coordinate system.

3) Spherical coordinate system.

15. How to represent a point in a Cartesian system?

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.

16. What is separation of vector?

The distance vector is also called as separation vector. Distance vector is nothing but the length of the vector.

17. State Distance formula?

Distance formula give the distance between the two points representing tips of the vector.

18. Show how a point p represented in a spherical coordinate system.

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 θ – Constant which is a right circular cone with apex as origin and axis as z axis.

Φ – Constant is a plane perpendicular to xy plane.

19. State the relationship between Cartesian and spherical system?

$x = r \sin\theta \cos\Phi$

$y = r \sin\theta \sin\Phi$

$z = r \cos\theta$

Now r can be expressed as

$x^2 + y^2 + z^2 = r^2 \sin^2\theta \cos^2\Phi + r^2 \sin^2\theta \sin^2\Phi + r^2 \cos^2\theta$

$= r^2 \sin^2\theta [\sin^2\Phi + \cos^2\Phi] + r^2 \cos^2\theta$

$= r^2 [\sin^2\theta + \cos^2\theta]$

$= r^2$

20. What are the types of integral related to electromagnetic theory?

1. Line integral
2. Surface integral
3. Volume integral

21. Give the types of charge distribution.
1. Line charge
2. Point charge
3. Surface charge
4. Volume charge.

Part B - Sixteen Marks

1. (a) State and prove divergence theorem.
   (b) What are the major sources of electromagnetic fields.

2. Check validity of the divergence theorem considering the field D=2xy ax+x^2ay c/m^2 and the rectangular parallelepiped formed by the planes x=0,x=1,y=0,y=2 & z=0,z=3. 3. A vector field D = [5r^2/4]Ir is given in spherical co-ordinates. Evaluate both sides of divergence theorem for the volume enclosed between r=1& r=2.

3. Explain three co-ordinate systems.

4. State and prove Gauss law and explain applications of Gauss law.

5. Derive an expression for the electric field due to a straight and infinite uniformly chargedwire of length 'L' meters and with a charge density of +λ c/m at a Point P which lies along the perpendicular bisector of wire.

6. A circular disc of radius 'a' m is charged uniformly with a charge density of σ c/ m^2.find the electric field at a point 'h' m from the disc along its axis.

7. Define the potential difference and absolute potential. Give the relation between potentialand field intensity.

8. Derive an expression for potential due to infinite uniformly charged line and also derivepotential due to electric dipole.

UNIT II – CONDUCTORS AND DIELECTRICS

Part A - Two Marks

1. Define point charge.

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.

One coulomb of charge is defined as the charge possessed by $(1/1.602x10^{-19})$ i.e $6x10^{18}$ number of electrons.

3. What are the various types of charge distribution? Give an example for each.

1. Point charge - Ex. Positive charge
2. Line charge - Ex. A sharp beam in a cathode ray tube.
3. Surface charge - Ex. The plate of a charged parallel plate capacitor.
4. Volume charge - Ex. The charged cloud.

4. State the assumptions made while defining a Coulomb's law.

1) The two charges are stationary.
2) The two charges are point charge.

5. What is an equipotential surface?

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?

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

7. Define electric flux density.

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.

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.

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?

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.

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.

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.

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

14. What is Potential Gradient?

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 Gaussiansurface?

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?

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

17. Define Absolute potential.

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?

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?

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. What is method of images?

The replacement of the actual problem with boundaries by an enlarged region or with image charges but no boundaries is called the method of images.

21. When is method of images used?

Method of images is used in solving problems of one or more point charges in the presence of boundary surfaces.

Part B - Sixteen Marks

1. Derive the boundary conditions of the normal and tangential components of electric field atthe interface of two media with different dielectrics.

2. Derive an expression for the capacitance of a parallel plate capacitor having two dielectricmedia.

3. Prove Laplace's and Poisson's equations.

4. Derive an expression for the capacitance of two wire transmission line.

5. Briefly explain about the application of Poisson's and Laplace's equations.

6. Derive the expression for co-efficient of coupling.

7. Briefly explain about the wave incident
   (i) Normally on perfect conductor
   (ii) Obliquely to the surface of perfect conductor.

8. Derive an expression for capacitance of co-axial cable.

UNIT III – STATIC MAGNETIC FIELDS

Part A - Two Marks

1. What is Magnetic Field?

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

2. What are Magnetic Lines of Force?

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.

3. State Stoke Theorem.

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.

4. Define scalar magnetic Potential.

The scalar magnetic potential V_m can be defined for source free region where *J* i.e. current density is zero.

5. What is the fundamental difference between static electric and magnetic field lines?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.

6. State Kirchoff's Flux law.

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.

7. State Kirchoff's MMF law.

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.

8. What is Magnetization?

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

9. State Biot Savart Law.

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

1) Proportional to the product of the current I and differential length dL.
2) The sine of the angle between the element and the line joining point p to the element and3) Inversely proportional to the square of the distance R between point p and the element.

10. Describe what are the sources of electric field and magnetic field?

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

11. Define Magnetic flux density.

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 Wb/m^2.

12. State Ampere's circuital law.

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

13. Define Magnetic field Intensity.

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: N/Wb.

14. What is rotational and irrotational vector field?

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.

15. Give the application of Stoke's theorem.

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 - Sixteen Marks

1. Derive the expression for magnetic field intensity and magnetic flux density due to finiteand infinite line.

2. Derive the expressions for magnetic field intensity and magnetic flux density due tocircular coil.

3. Derive an expression for force between two current carrying conductors.
4. State Ampere's circuital law and explain any two applications of Ampere's circuital law.

5. Derive the expression for the magnetic field intensity due to rectangular coil carryingcurrentI in a uniform field. Deduce the equation to find the H due to square coil.

6. State Ampere's circuital law and prove the same.

7. Find the magnetic field intensity at the centre O of a square loop of sides equal to 5M andcarrying 10A of current.

8. An iron ring with a cross sectional area of 3cm square and mean circumference of 15 cm iswound with 250 turns wire carrying a current of 0.3A. The relative permeability of ring is 1500. Calculate the flux established in the ring.

UNIT IV – MAGNETIC FORCES AND MATERIALS

Part A - Two Marks

1. Define Inductance.

In general, inductance is also referred as self inductance as the flux produced by the current flowing through the coil links with the coil itself.

2. What is fringing effect?

If there is an air gap in between the path of the magnetic flux, it spreads and bulges out. This effect is called fringing effect.

3. Define self inductance.

Self inductance is defined as the rate of total magnetic flux linkage to the current through the coil.

4. What is Magnetostatics?

The study of steady magnetic field, existing in a given space, produced due to the flow of direct current through a conductor is called Magnetostatics.

5. Define Right hand Thumb Rule and where it is used?

Right hand Thumb Rule states that, hold the current carrying conductor in the right hand such that the thumb pointing in the direction of current and parallel to the conductor, then curled fingers point in the direction of magnetic lines of flux around it. It is used to determine the direction of Magnetic field around a conductor carrying a direct current.

6. Define Right handed Screw Rule.

It states that, imagine a right handed screw to be along the conductor carrying current with its axis parallel to the conductor and tip pointing in the direction of the current flow. Then the direction of Magnetic field is given by the direction in which screw must be turned so as to advance in the direction of current flow.

7. Define Mutual inductance.

The mutual inductance between the two coils is defined as the ratio of flux linkage of one coil to the current in other coil.

8. Define Reluctance.

Reluctance R is defined as the ratio of the magneto motive force to the total flux.

9. What is Lorentz force equation?

Lorentz force equation relates mechanical force to the electrical force. It is given as the total force on a moving charge in the presence of both electric and magnetic fields.

10. Define Moment of force.

The Moment of a force or torque about a specified point is defined as the vector product of the moment arm *R* and the force *F*. It is measured in Nm.

11. Define Magnetic dipole moment.

The Magnetic dipole moment of a current loop is defined as the product of current through the loop and the area of the loop, directed normal to the current loop.

12. Give any two dissimilarities between electric and magnetic circuits.

1) In electric circuit the current actually flows i.e. there is a movement of electrons whereasin magnetic circuit, due to MMF, flux gets established and doesn't flow in the sense in which current flows.

2) The electric lines of flux are not closed. They start from positive charge and end onnegative charge and the magnetic lines of flux are closed lines.

13. What is Curl?

The curl is a closed line integral per unit area as the area shrinks to a point. It gives the circulation per unit area i.e. circulation density of a vector about a point at which the area is going to shrink. The curl also gives the direction, which is along the axis through a point at which curl is defined.

14. What is permeability?

In magnetostatics, the *B and H* are related to each other through the property of the region in which current carrying conductor is placed. It is called permeability denoted as µ. It is the ability with which the current carrying conductor forces the magnetic flux through the region around it.

15. Distinguish between solenoid and toroid.

Solenoid is a cylindrically shaped coil consisting of a large number of closely spaced turns of insulated wire wound usually on a non magnetic frame. If a long slender solenoid is bent into the form of a ring and thereby closed on itself it becomes a toroid.

Part B - Sixteen Marks

1. Derive an expression for inductance of a solenoid.

2. Obtain the expression for the energy stored in magnetic field.

3. Show that the inductance of the cable L = µl/2p (ln b/a) H.

4. Determine the inductance of a solenoid of 2500 turns wound uniformly over a length of 0.25m on a cylindrical paper tube, 4 cm in diameter .the medium is air.

5. Derive an expression for magnetic field strength H, due to a current carrying conductor offinite length placed along the y-axis, at a point P in x-z plane and r distant from the origin.

6. Derive the expression for torque developed in a rectangular closed circuit carrying currentI in a uniform field.

7. Find the magnetic field density at appoint on the axis of a circular loop of a radius b thatcarries a current I.

8. Derive an expression for self and mutual inductances.

UNIT V – TIME VARYING FIELDS AND MAXWELL'S EQUATIONS

Part A - Two Marks

1. Define a wave.

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.

2. Mention the properties of uniform plane wave.

i) At every point in space, the electric field E and magnetic field H are perpendicular to each other. ii) The fields vary harmonically with time and at the same frequency everywhere in space.

3. Define intrinsic impedance or characteristic impedance.

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

4. Give the characteristic impedance of free space.

377ohms.

5. Define propagation constant.

Propagation constant is a complex number $\gamma = \alpha + j\beta$ where γ is propagation constant.

6. Define skin depth.

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

7. Define Poynting vector.

The pointing vector is defined as rate of flow of energy of a wave as it propagates. P =E X H

8. State Poynting's Theorem.

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.

9. Give the difficulties in FDM.

FDM is difficult to apply for problems involving irregular boundaries and non- homogeneous material properties.

10. Explain the steps in finite element method.

i) Discrimination of the solution region into elements. ii)
Generation of equations for fields at each element.
iii) Assembly of all elements. iv)
Solution of the resulting system.

11. State Maxwell's fourth equation.

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

12. State Maxwell's Third equation

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

13. State the principle of superposition of fields.

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

14. Define loss tangent.

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

15. Define reflection coefficient.

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

16. Define transmission coefficient.

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

17. What will happen when the wave is incident obliquely over dielectric – dielectricboundary?

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.

18. What are uniform plane waves?

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.

19. What is the significant feature of wave propagation in an imperfect dielectric?

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.

20. What is the major drawback of finite difference method?

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

21. Define power density.

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

22. What is Normal Incidence?

When a uniform plane wave incidences normally to the boundary between the media then it is known as normal incidence.

23. What is called attenuation constant?

When a wave propagates in the medium, it gets attenuated. The amplitude of the signal reduces. This is represented by attenuation constant α. It is measured in Neper per meter (NP/m). But practically it is expressed in decibel (dB).

24. What is phase constant?

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

25. How voltage maxima and minima are separated?

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

<u>Part B - Sixteen Marks</u>

1. With necessary explanation, derive the Maxwell's equation in differential and integralforms.

2. Write short notes on faradays law of electromagnetic induction.

3. The magnetic field intensity in free space is given as $H=H_0\sin\Theta$ yt A/m. Where $\Theta=\omega t-\beta z$ and β is a constant quantity. Determine the displacement current density.

4. (a) What is the physical significance of the poynting vector?
   (b) State and explain the poynting theorem.

5. Derive the general wave equation.

6. Derive an expression for energy stored and energy density in an Electrostatic field.
7. A plane wave propagating through a medium with $\varepsilon_r=8$, $\mu_r=2$ has $E=0.5\sin(10^8t-z)\beta z$ v/m. Determine (i) β (ii) The loss tangent (iii) wave impedance (iv) wave velocity (v) magnetic field.

8. Derive a wave equation for non dissipative medium making use of Maxwell equations andfield vectors E and H.

9. Define wave. Derive the free space electromagnetic wave equation.

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