EE3301– ELECTROMAGNETIC FIELDS

2 Marks -Question Bank

Unit 1- ELECTROSTATICS – I

1. Cartesian Co-ordinate System the Gradient of the function: f(r, θ,z)=5r^{4}z^3$\sin\theta$.(AU M/J 2014)

$$\nabla.F = \frac{\partial(5r^4z^3\sin\theta)}{\partial x}\overrightarrow{a_x} + \frac{\partial(5r^4z^3\sin\theta)}{\partial y}\overrightarrow{a_y} + \frac{\partial(5r^4z^3\sin\theta)}{\partial z}\overrightarrow{a_z} = 0+0+15r^4z^2\sin\theta\,\overrightarrow{a_z} =$$

$$15r^4z^2\sin\theta\overrightarrow{a_z}$$

2. Obtain in the Cylindrical Co-ordinate System the Gradient of the function: f(r, θ ,z)=5r^{4}z^3$\sin\theta$.(AU M/J 2012)

$$\nabla.F = \frac{1}{r}\frac{\partial(5r^4z^3\sin\theta)}{\partial r}\overrightarrow{a_r} + \frac{\partial(5r^4z^3\sin\theta)}{\partial \emptyset}\overrightarrow{a_\emptyset} + \frac{\partial(5r^4z^3\sin\theta)}{\partial z}\overrightarrow{a_z}$$

$$= 20z^3r^2\sin\theta\overline{a_r} + 5z^3r^4\sin\theta\overline{a_y} + 15z^2r^4\sin\theta\overline{a_z}$$

3. State stokes theorem.(AU M/J 2012,&2014,NOV/DEC 2013)

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

$$\oint H.dl = \oiint_s \nabla X H\, ds$$

4. Mention the sources of electromagnetic field?(AU-M/J 2013)

The sources of EMF are electrical lighting and appliances, computer monitors, microwave ovens, radios, TV, Cellular phones, broadcast stations, overhead lines and communication satellites.

5. State the physical significance of curl of a vector field? (AU-M/J 2013)

(∇XH) = 0. The physical significance of the curl of a vector field is the curl provides the maximum value of the circulation of the field per unit area indicates the direction along which this maximum value occurs. The curl of a vector field A at a point P may be regarded as a measure of the circulation or how much the field curls around P.

6. How is the unit vectors defined in cylindrical coordinate systems?(AU N/D 2013)

i. A unit vector is a dimensionless quantity of unit magnitude.

ii. The coordinates are r, ф and z are the units vector

$$\begin{bmatrix} a_\rho \\ a_\Phi \\ a_z \end{bmatrix} = \begin{bmatrix} \cos\Phi & \sin\Phi & 0 \\ -\sin\Phi & \cos\Phi & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} a_x \\ a_y \\ a_z \end{bmatrix}$$

7. **State the condition for the vector A to be (a) solenoidal (b) irrotational.(AU N/D 2012)**

(a) $\nabla \bullet A = 0$ (b) $\nabla \times A = 0$

8. **Two vectorial quantities $\vec{A} = 4\vec{i} + 3\vec{j} + 5\vec{k}$ and $\vec{B} = \vec{i} - 2\vec{j} + 2\vec{k}$ are known to be oriented in two unique directions. Determine the angular separation between them. (AU N/D 2012)**

$\vec{A} = 4\vec{i} + 3\vec{j} + 5\vec{k}$, $\vec{B} = \vec{i} - 2\vec{j} + 2\vec{k}$

Angular separation between them

$$\text{Cos}\,\theta = \vec{A}.\vec{B}/|\vec{A}||\vec{B}| = \frac{4-6+10}{\sqrt{16+9=25}} = \frac{8}{\sqrt{450}}$$

$$\theta = \cos^{-1}(0.377) = 67.844^{o}.$$

9. **What is the physical significance of div D?**

The divergence of a vector flux density is electric flux per unit volume leaving a small volume. This is equal to the volume charge density.

$$\nabla \bullet D = \rho_v$$

10. **Define divergence**

The divergence of a vector F at any point is defined as the limit of its surface integral per unit volume as the volume round the point shrinks to zero

$$\nabla . A = \underset{V \to 0}{Lt} \frac{1}{v} \oint A . \vec{n}\, ds$$

11. **What are a scalar field and a vector field?**

If at every point in a region, a scalar function has a defined value, the region is called a scalar field. Example: Temperature distribution in a rod.

If at every point in a region, a vector function has a defined value, the region is called vector field. Example: velocity field of a flowing fluid.

12. **Define Scalar and Vector and give examples.**

A scalar is a quantity that is completely characterized by its magnitude and algebraic sign. Eg. Mass, Work, etc. A Vector is a quantity that is completely characterized by its magnitude and direction. Eg. Force, Displacement, etc.

13. **Give the types of vectors with examples.**

There are two types of Vectors: Localized vectors and free vectors. Localized vectors are those for which the point at which the vector acts should also be specified whereas a free vector doesn't have such restriction. Eg. Force (Localized), Couple (Free).

14. **Define a unit vector and its value in Cartesian coordinate axis.**

Unit vector is having magnitude and directed along the coordinates axis.

For Cartesian coordinates $A = A_x a_x + A_y a_y + A_z a_z$ where a_x, a_y and a_z are unit vectors in the direction of x,y and z respectively.

15. What are the different types of coordinate systems?

a. Rectangular or Cartesian Coordinate Systems

b. Cylindrical Coordinate Systems

c. Spherical Coordinate Systems

16. State Coulomb's law.

Coulombs' law states that the force between two point charges is directly proportional to the product of magnitudes of the charges and inversely proportional to the square of the distances between the charges. The force is also dependent upon the medium in which the charge is placed. Q_1, Q_2 are point charges.

r – is the distance between two charges.

K – is a constant of proportionality and it depends on permittivity of the medium and is given by,

$\varepsilon_0 = 8.854 \times 10^{-12}$ F/m

$k = 9 \times 10^{9}$ m/F

17. State Gauss's law and give expression.

The Gauss's law states that the surface integral of the Electric field vector E over any closed surface in free space is given by Q/ε_0, where Q is the total charge enclosed by the surface.

18. Name few applications of Gauss law in electrostatics(AU NOV/DEC 2013)

Gauss law is applied to find the electric field intensity from a closed surface. e.g. Electric field can be determined for shell, two concentric shell or cylinders.

19. Write the expression for differential length in cylindrical and spherical co-ordinates.

i. For cylindrical coordinates $dl = [(d\rho)^2 + (\rho d\phi)^2 + (dz)^2]^{1/2}$

ii. For spherical coordinates $dl = [(dr)^2 + (rd\theta)^2 + (r\sin\theta\, d\phi)^2]^{1/2}$

20. Give the prosperities of vectors.

Vectors can exist at any point in space.

Vectors have both magnitude and direction.

Any two vectors that have the same direction and magnitude are equal no matter where they are located in space, this is called vector equality.

21. What is Unit Vector? What is function while representing vector?

a. A Vector which has magnitude unity and defining the same direction as given vector.

i. Vector addition obeys commutative law A +B = B +A

ii. Vector addition obeys associative law A + (B +C) = (A + B) + C

b. - A is also a vector. It has same magnitude; its direction is 180° away from direction of A.

A –B = A + (- B)

25. Show that the vector $H = 3y^4z^2\, a_x + 4x^3z^2 a_y + 3x^2y^2 a_z$ is solenoid

$\nabla . H = 0$

$= \frac{\partial}{\partial x}(3y^4z^2) + \frac{\partial}{\partial y}(4x^3z^2) + \frac{\partial}{\partial z}(3x^2y^2) = 0$

26. Points P and Q are located at (0,2,4) and (-3,1,5). Calculate the distance vector from P to Q. (AU-N/D2014)

$$r_Q - r_P = (-3-0)\bar{a}_x + (1-2)\bar{a}_y + (5-4)\bar{a}_z$$

$$= -3\bar{a}_x - 2\bar{a}_y + \bar{a}_z$$

26. Determine the electric flux density at a distance of 20 cm due to an infinite sheet of uniform charge 20μC/m² lying on the z=0 plane. (AU-N/D2014)

$$E = \frac{\rho_s}{2\varepsilon}(1 - cos\alpha)$$

$$= \frac{20X10^{-6}}{2X8.854X10^{-12}}(1 - \cos 90)$$

$$= 1.29X10^6\ V/m$$

26. Given $A = 4a_x + 6a_y - 2a_z \ and \ B = -2a_x + 4a_y + 8a_z$. Show that the vectors are orthogonal.

$$\bar{A}.\bar{B}\ should\ be\ equal\ to\ zero$$

$$\bar{A}.\bar{B} = -8 + 24 - 16 = 0$$

Hence the vectors A & B are orthogonal

26. Express in matrix form the unit vector transformation from the rectangular to cylindrical co-ordinate system.

$$\begin{bmatrix} a_\rho \\ a_\Phi \\ a_z \end{bmatrix} = \begin{bmatrix} cos\Phi & sin\Phi & 0 \\ -sin\Phi & cos\Phi & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} a_x \\ a_y \\ a_z \end{bmatrix}$$

27. Find the force of interaction between two charges $4*10^{-8}$ and $6*10^{-5}$ spaced 10cm apart in kerosene. (ε_r=2.0)

$$F = \frac{Q_1 Q_2}{4\pi\varepsilon r^2}$$

= 0.1079 Newtons

Unit 2- ELECTROSTATISTICS- II

1. What is Electric potential? (AU NOV/DEC 2013)

The Electric potential is a scalar quantity and is found to be equal to the work done per unit charge in moving a test charge against the field from a reference point, say from infinity to its final position.

$$=\frac{\qquad}{\varepsilon_0 r} \quad \text{Volts}$$

2. Write the boundary conditions at the interface between two perfect dielectrics.

i)Dn1= Dn2

ii)Et1=Et2

3. Define potential difference.(AU NOV/DEC 2013)

Potential difference is defined as the work done in moving a unit positive charge from one point to another point in an electric field.

4. State Poisson's and Laplace's Equation.(AU MAY/JUNE 2014)

Poisson 's eqn: $\nabla^2 V = -\rho_v / \varepsilon$

Laplace' s eqn: $\nabla^2 V = 0$

5. Calculate the capacitance of a parallel plate capacitor having an electrode area of $100cm^2$. The distance between the electrodes is 4mm and the dielectric used as a permitivity of 3.5. The applied voltage is 100V. (AU MAY/JUNE 2014)

6. State the properties of electric flux lines (AU-A/M 2013,N/D2014)

It is independent of the medium

Its magnitude depends only upon the charge from which it is originated

If a point charge in enclosed in an imaginary sphere of radius R, the electric flux must pass perpendicularly and uniformly through the surface of the sphere.

7. A dielectric slab of flat surface with relative permittivity 4 is disposed with its surface normal to a uniform field with flux density 1.5 C/m^2. Th slab is uniformly polarized. Determine polarization in the slab. (AU-A/M 2013)

Polarization P = $\Psi\varepsilon_o E$, D = $\varepsilon_o \varepsilon_r E$, $\Psi = \varepsilon_r - 1$

$$P = \frac{\varepsilon r - 1}{\varepsilon r} = \frac{4-1}{4} \times 1.5 = 1.125\ C/m^2$$

8. Show that $\nabla . E = 0$ in case of apoint charge.(AU- M/J 2012)

$E = \frac{Q}{4\pi\varepsilon r^2}\vec{a}_r$ for point charge, then $\nabla . E = 0$

9. At the boundary between copper and aluminum the electric field lines maked as an angle of 45° with the normal to the interface. Find the angle of emergence. The conductivity of copper and aluminum are 5.8 x 10^5 S/cm and 3.5 X 10^5 S/cm, receptively (AU- M/J 2012)

$\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$ $\theta_2 = 31.10^{o}$

10. Give the expression for Electrostatic energy.

Let W_E be the energy stored in static electric field of charge distribution. If the field has 'n' point charges, then

$$W_E = \frac{1}{2}\sum_{m=1}^{m=n} Q_m V_m \quad \text{Joules}$$

where Q_m is the charge of m^{th} point charge and V_m is the potential at point 'm'.

11. What is a parallel plate capacitor?

A parallel plate capacitor is a capacitor with two parallel conducting plates separated by a distance 'd'. The region between the plates contains a dielectric. When a potential V is applied the positive charges get stored in the upper plate and negative charges get stored in the lower plates.

12. What is Capacitance? Give expression.

The ratio of the absolute value of the charge to the absolute value of the voltage difference is defined as the capacitance of the system.

13. State Gauss law for magnetic field.

The total magnetic flux passing through any closed surface is equal to zero.

B.ds =0

14. Define potential.

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.

$V=Q / 4\pi\varepsilon r$

15. Write poisson's and laplace 's equations.

Poisson 's eqn: $\nabla^2 V = -\rho_v / \varepsilon$

Laplace' s eqn: $\nabla^2 V = 0$

16. What are the significant physical differences between Poisson 's and laplace 's equations? (AU-N/D2014)

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 in a known distribution ρ_v poissons equation can be used to find the potential. When the region is free from charge ($\rho=0$) laplace equation is used to find the potential.

17. Explain the conservative property of electric field.

The work done in moving a point charge around a closed path in a electric field is zero. Such a field is said to be conservative. E.dl = 0

18. Define Dipole

The equal and opposite charges are separated by a small distance is called Dipole.

19. Define Dipole Moment

The product of charge and spacing between the poles is called dipole moment

M= Q.d

20. Define Polarization

Polarization is defined as the dipole moment per unit volume.

P = Ql/V

21. Define dielectric strength of material.

The dielectric strength of a material is defined as the maximum value of electric field that can be applied to the dielectric without its electric breakdown.

22. What are dielectrics?

Dielectrics are materials that may not conduct electricity through it but on applying electric field induced charges are produced on its faces .The valence electron in atoms of a dielectric are tightly bound to their nucleus.

31. Show that $\nabla . E = 0$ in case of apoint charge.(AU- M/J 2012)

E = $\frac{Q}{4\pi\varepsilon r^2}\vec{a}_r$ for point charge, then $\nabla . E = 0$

32. At the boundary between copper and aluminum the electric field lines maked as an angle of 45° with the normal to the interface. Find the angle of emergence. The conductivity of copper and aluminum are 5.8 x 10^5 S/cm and 3.5 X 10^5 S/cm, receptively (AU- M/J 2012)

$\frac{\tan\theta_1}{\tan\theta_2} = \frac{\varepsilon_1}{\varepsilon_2}$ $\theta_2 = 31.10°$

33. Compare the equi-potential plots of uniform and non-uniform fields. (AU-A/M2015)

In a uniform field E-lines are parallel & the equipotential lines form a parallel orthogonal set of lines. In a non-uniform field E-lines & the corresponding equipotential lines are divergent.

For a given potential difference, the equipotential surfaces are equally spaced in the case of a uniform field. In case of a non-uniform field, the spacing increases as the field gets weakened.

22. Give the Laplace equation in Cartesian, Cylindrical and Spherical co-ordinate systems.

Laplace Equation in Cartesian co-ordinates

$$\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = 0$$

Laplace Equation in Cylindrical co-ordinates

$$\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial V}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2} = 0$$

Laplace Equation in Spherical co-ordinates

$$\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial V}{\partial r}) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}(\sin\theta\frac{\partial V}{\partial \theta}) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 V}{\partial \phi^2} = 0$$

23. Give the Poisson's equation in Cartesian, Cylindrical and Spherical co-ordinate systems.

Poisson Equation in Cartesian co-ordinates

$$\nabla^2 V = \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} + \frac{\partial^2 V}{\partial z^2} = -\frac{\rho}{\varepsilon}$$

Poisson Equation in Cylindrical co-ordinates

$$\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}(r\frac{\partial V}{\partial r}) + \frac{1}{r^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2} = -\frac{\rho}{\varepsilon}$$

Poisson Equation in Spherical co-ordinates

$$\nabla^2 V = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2\frac{\partial V}{\partial r}) + \frac{1}{r^2 \sin\theta}\frac{\partial}{\partial \theta}(\sin\theta\frac{\partial V}{\partial \theta}) + \frac{1}{r^2 \sin^2\theta}\frac{\partial^2 V}{\partial \phi^2} = -\frac{\rho}{\varepsilon}$$

Unit III- MAGNETOSTATICS

1. What is Lorentz law of force?(AU NOV/DEC 2013)

The Lorentz force equation gives the force on a charge Q moving in a region where both the electric field E and magnetic field B are present.

$$F = Q\ (E + v \times B)\quad N$$

Where v is the velocity with which the charge moves in the field.

2. State Ampere's Circuital law (AU MAY/JUNE 2014) (AU-M/J 2012)

The Ampere's law states that the line integral of H around a single closed path is equal to the current enclosed. It can also be stated as the line integral of B around a single closed path is equal to the permeability of the medium times the current enclosed.

3. Write down the magnetic boundary condition. (AU NOV/DEC 2013)

The normal component of flux density B is continuous across the boundary.

The tangential component of field intensity H is continuous across the boundary

4. Write the expression for inductance per unit length of a long solenoid of N turns and having a length 'l' mtr carrying a current of I amperes (AU-M/J 2014)

Inductance L = $\frac{\mu_0 N^2 A}{l}$, where N- no of turns, A- area of cross section of the solenoid in m^2, l- length of a solenoid in meter

5. Find the value of magnetic field intensity at the centre of a circular loop of radius 1m carrying a current of 10 A (AU-M/J 2013)

H = $\frac{I}{2a}$ = 10/2 = 5 H

6. Write the expression for the magnetic force between an electromagnet and an attracted armature relay. (AU-M/J 2013)

F = $\frac{B^2 A}{2\mu_0}$ K gm f, where B- magnetic flux density in tesla

7. Find the inductance per unit length of a solenoid of N turns and having a length 'L' mtrs. Assume that its carries a current of I amperes **(AU-M/J 2012)**

H= $\frac{N I}{l}$ H, N- no of turns, I- current in ampere, l – length in meters

8. What is the torque on a current carrying loop?

The torque, or moment, of a force is a vector whose magnitude is the product of the magnitudes of the vector force, the vector lever arm, and the sine of the angle between these two vectors. The direction of the vector torque is normal to both the force and lever arm.

9. **Give the expressions relating B and H with the current density J.**

$$B = \frac{\mu_0}{4\pi} \quad \frac{J \times a_r}{r^2} dv$$

$$cur\ B = \mu_0$$

10. **What is the torque on a planar coil?**

The torque on a planar coil of any size in a uniform magnetic field is the product of the magnitudes of magnetic moment 'm', magnetic flux density B and the sine of the angle between these two. It is given by

11. **Define magnetic field strength**.

The magnetic field strength (H) is a vector having the same direction as magnetic flux density.

H=B/μ

12. **Define inductance**.

The inductance of a conductor is defined as the ratio of the linking magnetic flux to the current producing the flux. L = Nφ / I

13. **Give the formula to find the force between two parallel current carrying conductors**.

$F = \mu I_1 I_2 / 2ðR$

14. **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.

15. **Define magnetic vector potential**.

It is defined as that quantity whose curl gives the magnetic flux density.

B= ▼ x A=μ / 4πJ/r dv web/m^2

16. **Define magnetization**

Magnetization is defined as the magnetic dipole moment per unit volume.

17. **Define magnetic susceptibility**.

Magnetic Susceptibility is defined as the ratio of magnetization to the magnetic field intensity.

18. **Classify the magnetic materials**.

I) Dia magnetic

II) Paramagnetic

III) Ferromagnetic

19. **Define dielectric strength**.

The maximum E that a dielectric material can with stand without break down is the dielectric strength of the material.

20. **Determine the value of magnetic field intensity at the centre of a circular loop carrying a current of 10A. The radius of the loop is 2m**. **(AU-N/D2014)**

$$H = \frac{I}{2a}\ A/m$$

$$= \frac{10}{2X2} = 2.5A/m$$

21. Distinguish between magnetic scalar potential and magnetic vector potential. (AU-N/D2014)

Magnetic scalar potential	Magnetic scalar potential
It is defined as dead quantity whose Negative gradient gives the magnetic intensity if there is no current source present.	It is defined as that quantity whose curl gives the magnetic flux density.
$\mathbf{H} = -\nabla \mathbf{V}_m$	$\mathbf{B} = \nabla \mathbf{X} \mathbf{A}$

25. What is the practical significance of Lorentz's force? (AU-A/M2015)

Lorentz's force equation relates mechanical force to the electrical force. If the mass of the charge is m, then

$$F = m\bar{a} = m\frac{dv}{dt} = Q(\bar{E} + \bar{V}X\bar{B})Newton$$

26. Find the maximum torque on an 100 turns rectangular coil of 0.2 m by 0.3 m, carrying current of 2A in the field of flux density 5Wb/m^2. (AU-A/M2015)

Torque=BIA

= (5) (2)[0.2X0.3]

= 0.6 Nm

27. Define Mutual inductance and Self inductance.

Mutual Inductance: It is defined as the ratio of induced magnetic flux linkage in one coil to the current through the other coil.

$$M = N_1\frac{\Phi_{21}}{I_2} \qquad M = N_2\frac{\Phi_{12}}{I_1}$$

Self inductance: It is the property of a circuit by which change in current induces emf in the circuit to oppose the change in current.

$$L = \frac{N\Phi}{I}\ H$$

Unit IV- ELECTRODYNAMIC FIELDS

1. **A Parallel plate capacitor has an electrode area of 10cm^2. The separation between the plates is 5mm. A voltage of 10 sin 100 πt is applied across its plates. Calculate its displacement current. Assume air dielectric (AU-M/J 2014)**

   E= 10 sin πt

   $J_D = \varepsilon_o \varepsilon_r \frac{\partial E}{\partial t}$ =8.854 X 10^{-12} $\frac{\partial(10 \sin \pi t)}{\partial t}$ = 88.54 X10^{-12} cos πt V/m

2. **What is Displacement current (AU-N/D 2013)**

Displacement current I_D is flowing through a capacitor when ac voltage is applied across the capacitor.

3. **Distinguish between transformer emf and motional emf (AU-N/D 2013, A/M2015)**

   The emf induced in a stationary conductor due to the change in flux linked with it, is called transformer emf or static induced emf

   Emf = - $\iint \frac{\partial B}{\partial t}$.ds , eg : transformer

   The emf induced due to the movement of conductor in a magnetic field is called motional emf or dynamic induced emf

   Emf = $\oint_c v \, X \, B.dl$, eg: generator

4. **What type of voltage is induce in a loop which is rotating about the y-axis in a magnetic field of flux density $\vec{B}$ = B_o sin ωt $\bar{i}$ Tesla? (AU-M/J 2013)**

   Motional emf or dynamic induced emf

5. **Write the relation showing the energy required to establish a magnetic field by a quasi-stationary current system. (AU-M/J 2013)**

   W = $\frac{1}{2} LI^2$, L- inductance in H, I - current in A

6. **What is an emf?**

   An electro-motive force is a voltage that arises from conductors moving in a magnetic field or from changing magnetic fields.

7. **State Faraday's law.**

   Faraday's law states that, the total emf induced in a closed circuit is equal to the time rate of decrease of the total magnetic flux linking the circuit.

8. **State Lenz's law.**

The Lenz's law states that, the induced current in the loop is always in such a direction as to produce flux opposing the change in flux density.

9. Explain briefly the different types of emf's produced in a conductor placed in a magnetic field.

There are two ways in which we can induce emf in a conductor. If a moving conductor is placed in a static magnetic field then the emf produced in the conductor is called dynamically induced emf. If the stationary conductor is placed in a time varying magnetic field, then the emf produced is called statically induced emf.

10. Give the Maxwell's equation – I in both integral form and point form.

Maxwell's equation – I is derived from the Ampere's circuital law which states that the line integral of magnetic field intensity H on any closed path is equal to the current enclosed by that path.

Maxwell's equation – I in integral form is

$$\oint H.dl = \int_s \left(\sigma E + \varepsilon \frac{\partial E}{\partial t} \right) ds$$

Maxwell's equation – I in point form is

$$\nabla \times H = \sigma E + \varepsilon \frac{\partial E}{\partial t}$$

The magneto motive force around a closed path is equal to the sum of the conduction current and displacement current enclosed by the path.

11. Give the Maxwell's equation – II in both integral form and point form.

Maxwell's equation – II is derived from Faraday's law which states that the emf induced in a circuit is equal to the rate of decrease of the magnetic flux linkage in the circuit.

Maxwell's equation - II in integral form is

$$\oint E.dl = -\mu \int \frac{\partial H}{\partial t} ds$$

Maxwell's equation – II in point form is

$$\nabla \times E = -\frac{\partial B}{\partial t}$$

The electro motive force around a closed path is equal to the magnetic displacement (flux density) through that closed path.

12. Distinguish between the conduction current and displacement current.

Conduction current I_c is flowing through a conductor having resistance R, when potential V is applied across the conductor.

Displacement current I_D is flowing through a capacitor when ac voltage is applied across the capacitor.

13. What is Eddy current and Eddy current loss?

In electrical machines, the alternating magnetic fields induce emf in the cores also apart from the coil. This small amount of emf induced in the core circulates current in the core. This current is called eddy current and the power loss, which appears in the form of heat, due to these eddy currents is called eddy current loss.

14. Write the point form of continuity equation and explain its significance.

$$\nabla \bullet J = - \rho v / \varepsilon$$

15. State point form of ohms law.

Point form of ohms law states that the field strength within a conductor is proportional to the current density.$J = \sigma E$

16. Write down the magnetic boundary conditions.

The normal components of flux density B are continuous across the boundary.

The tangential component of field intensity is continuous across the boundary.

17. 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.

18. Define ohms law at a point

Ohms law at appoint states that the field strength within a conductor is proportional to current density.

19. State electric displacement.

The electric flux or electric displacement through a closed surface is equal to the charge enclosed by the surface.

20. What is displacement flux density?

The electric displacement per unit area is known as electric displacement density or electric flux density.

21. What is the significance of displacement current?

The concept of displacement current was introduced to justify the production of magnetic field in empty space. It signifies that a changing electric field induces a magnetic field .In empty space the conduction current is zero and the magnetic fields are entirely due to displacement current.

22.

<u>**Circuit Theory**</u>	<u>**Field theory**</u>
1) Low power is involved	High power is involved
2) Simple to understand	needs visualization ability
3) Two dimensional analysis	three dimensional analysis
4) Laplace transform is involved	Maxwell equation is employed

25. State continuity equation (AU-M/J 2012)

$\nabla . J = -\frac{\partial \rho_v}{\partial t}$. Since the charge is conserved, the outside flux of J must therefore be equal to the rate of loss of charge within the volume.

26. State Ohm's law for magnetic circuits. (AU-A/M 2014)

Ohm's law for magnetic circuit establishes the relationship between flux, mmf & reluctance.

Reluctance=mmf/flux

mmf = Reluctance X flux

Unit V- ELECTROMAGNETICS WAVES

1. **Calculate the characteristic impedance of free space. (AU-N/D 2012)**

   377ohms

1. **Define Poynting vector.**

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

   P =E X H

2. **State Poyntings Theorem. (AU-M/J 2014) (AU-N/D 2013)**

   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.

3. **Define pointing vector.**

   The vector product of electric field intensity and magnetic field intensity at a point is a measure of the rate of energy flow per unit area at that point.

4. **Mention any two properties of uniform plane wave. (AU-N/D 2013)**

   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.

5. **Define characteristic impedance or intrinsic impedance**

   Characteristic impedance is defined as the ratio of square root of permeability to the dielectric constant of the medium. It is also defined as the ratio of electric field intensity to the magnetic field intensity.

6. **What is voltage standing wave ratio? (AU-N/D 2012)**

   The ratio of maximum to minimum magnitudes of voltage or current on a line having standing wave is called standing ration SRW = $\left|\frac{V_{max}}{V_{min}}\right| = \left|\frac{I_{max}}{I_{min}}\right|$

7. **Define standing wave ratio(AU-M/J 2013) (AU-M/J 2014)**

   The ratio of maximum to minimum magnitudes of voltage or current on a line having standing wave is called standing ration SRW = $\left|\frac{V_{max}}{V_{min}}\right| = \left|\frac{I_{max}}{I_{min}}\right|$

8. **Obtain the depth of penetration in copper at 2MHz, given the conductivity of copper $\sigma = 5.8\,X\,10^7 S$/m and its permeability = 1.26 μH/m. (AU-M/J 2014)**

   $\omega = 2\pi f,\ \ \mu = 4\pi\,X\,10^{-7}\ H/m$

   $\delta = \sqrt{\frac{2}{\omega\mu\sigma}} = \sqrt{\frac{2}{(2\pi\,X\,2\,X\,10^6 X\,4\pi\,X\,10^{-7} X\,5.8\,X\,10^7)}} = 4.67\text{x } 10^{-5}$ m

9. **What is voltage reflection coefficient at the load end of the transmission line? (AU-M/J 2013)**

Voltage across the wire at the end must be zero, incident and reflected voltages cancel

$\rho_v = \frac{z_2 - z_1}{z_2 + z_1}$ **= -1**

10. Give the wave equation in terms of electric field and magnetic field.

The electromagnetic wave equation in terms of electric field is,

$$\nabla^2 E - \mu\sigma \frac{\partial E}{\partial t} - \mu\varepsilon \frac{\partial^2 E}{\partial t^2} = 0$$

The electromagnetic wave equation in terms of magnetic field is,

$$\nabla^2 H - \mu\sigma \frac{\partial H}{\partial t} - \mu\varepsilon \frac{\partial^2 H}{\partial t^2} = 0$$

11. Give the wave equation in free space.

The wave equation in free space in terms of electric field is,

$$\nabla^2 E - \mu\varepsilon \frac{\partial^2 E}{\partial t^2} = 0$$

The wave equation in free space in terms of magnetic field is,

$$\nabla^2 H - \mu\varepsilon \frac{\partial^2 H}{\partial t^2} = 0$$

12. List out the properties of a uniform plane wave.

If the plane of wave is the same for all points on a plane surface, it is called plane wave. If the amplitude is also constant in a plane wave, it is called uniform plane wave. The properties of uniform plane waves are:

a) At every point in space, E and H are perpendicular to each other and to the direction of travel.

b) The fields vary with time at the same frequency, everywhere in space.

c) Each field has the same direction, magnitudes and phase at every point in any plane perpendicular to the direction of wave travel

13. Give the expression for the characteristic impedance of the wave.

i) The characteristic impedance or intrinsic impedance is the ratio of the electric field intensity to the magnetic field intensity.

14. What is Vector Helmholtz equation.

i) The wave equation in lossless medium in phasor form is called the vector Helmholtz equation.

$$\nabla^2 E + \mu\varepsilon\omega^2 E = 0$$

15. Give the wave equation for a conducting medium.

i) The wave equation for a conducting medium in phasor form is given as,

$$\nabla^2 E - j(\omega\mu\sigma + j\mu\varepsilon\omega^2)E = 0$$

16. What is skin effect and skin depth?

i) In a good conductor the wave is attenuated as it progresses. At higher frequencies the rate of attenuation is very large, and the wave may penetrate only a very short distance before being reduced to a small value. This effect is called skin effect.

ii) The skin depth (δ) is defined as that depth in which the wave has been attenuated to 1/e or approximately 37% of its original value. It is also known as depth of penetration.

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left(\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}} - 1\right)}$$

17. Give the expression for attenuation constant and phase shift constant for a wave propagating in a conducting medium.

i) The attenuation constant for a wave propagating in a conducting medium is,

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left(\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}} - 1\right)}$$

ii) The phase shift constant for a wave propagating in a conducting medium is,

$$\beta = \omega\sqrt{\frac{\mu\varepsilon}{2}\left(\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}} + 1\right)}$$

18. Give the expression for the velocity of propagation of a wave in any medium.

The velocity of propagation of a wave in any medium is,

$$v = \frac{\omega}{\ } = \frac{1}{\sqrt{\mu\varepsilon}}$$

where ω is the angular velocity and β is the phase shift.

19. 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.

20. 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.

21. What is the effect of permittivity on the force between two charges?

Increase in permittivity of the medium tends to decrease the force between two charges and decrease in permittivity of the medium tends to increase the force between two charges.

22. Define loss tangent.

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

23. Define reflection and transmission coefficients.

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

24. Define transmission coefficients.

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

25. How can the eddy current losses be eliminated?

The eddy current losses can be eliminated by providing laminations. It can be proved that the total eddy current power loss decreases as the number of laminations increases.

26. 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 terminates on charges, whereas magnetic flux tubes are continuous.

27. 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.

28. 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.

30. Obtain the depth of penetration in copper at 2MHz, given the conductivity of copper

$\sigma = 5.8\,X\,10^7 S$/m and its permeability = 1.26 μH/m. (AU-M/J 2014)(AU-M/J 2012)

$\omega = 2\pi f,\ \ \mu = 4\pi\,X\,10^{-7}\ H/m$

$\delta = \sqrt{\frac{2}{\omega\mu\sigma}} = \sqrt{\frac{2}{(2\pi\,X\,2\,X\,10^6 X\,4\pi\,X\,10^{-7} X\,5.8\,X\,10^7)}}$ = 4.67x 10^{-5} m

31.A plane wave travelling in free space has an average power of 2 W/m^2. Find the average energy density

Energy density = ½ μH^2 = ½ εE^2

32. The capacitance and inductance of an overhead transmission line are 0.0075µF/km and 0.8 mH/km respectively. Determine the characteristic impedance of the line. (AU-N/D2014)

$$Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{0.8X10^{-3}}{0.0075X10^{-6}}} = 326.59\ A/m$$

33. If a plane wave is incident normally from medium 1 to 2. Write the reflection and transmission coefficients. (AU-N/D2014)

$$Reflection\ coefficient = \frac{E_r}{E_i} = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1}$$

$$Transmission\ coefficient = \frac{E_t}{E_i} = \frac{2\eta_2}{\eta_2 + \eta_1}$$

34. What is the wavelength and frequency of a wave propagation in free space when β =2? . (AU-A/M2015)

$$\beta = \frac{2\pi}{\lambda}, \qquad \lambda = \frac{2\pi}{\beta} = 3.14m$$

$$f = \frac{v_o}{\lambda}$$

$$f = \frac{3X10^8}{3.14} = 95.5MHz$$