SAMSKRUTI COLLEGE OF ENGINEERING & TECHNOLOGY

Department of Electrical and Electronics Engineering

Hand Out

Subject Name: Electromagnetic Fields

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Year and Sem, Department: II Year I Sem,EEE

Unit-I (Important points)

1.Coulomb's Law : $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{R^2}$

2. The electric field intensity or the electric field strength at a point is defined as the force per unit charge.

3. The electric flux as : $\psi = \int_S \vec{D}.d\vec{s}$

4. Gauss's law is one of the fundamental laws of electromagnetism and it states that the total electric flux through a closed surface is equal to the total charge enclosed by the surface.

5. The potential difference between two points P and Q , VPQ, is defined as the work done per unit charge, i.e. $V_{PQ} = \frac{W}{\Delta Q} = -\int_P^Q \vec{E}\cdot d\vec{l}$

6. The divergence represents the volume density of the outward fluxof a vector field from an infinitesimal volume around a given point.

7. Relation Between E and V is $\vec{E} = -\nabla V$

8. Poisson's equation is : $\nabla.\nabla V = \nabla^2 V = -\frac{\rho_v}{\varepsilon}$

9. Laplace's equation is $\nabla^2 V = 0$

10. **Electric dipole:** The name given to two point charges of equal magnitude and opposite sign, separated by a distance which is small compared to the distance to the point P, at which we want to know the electric and potential fields

Unit-I (2 Marks Questions)

1. What do mean by Electrostatic field and how can you say it is conservative.[Mar-2016]
2. Determine the force between two charges 3×10^{-4} C at P (1, 2, 3) and -10^{-4} C at Q (2, 0, 5) in vacuum.[Mar-2016]
3. State the expression for the force between one charge point to an array of a charge points?
4. What are the properties of potential function?[Nov-2016]
5. What are the limitations of Coulomb's law?[Nov-2017]
6. Define dipole and dipole moment.[Nov-2017]
7. State coulomb's law of electric charge.
8. What is Maxwell's first law?[N0v-2017][N0v-2016]
9. Define electric dipole.[Nov-2016]
10. Define electric field intensity and electric potential and write the relationship between them.[N0v-2017][May-2018]
11. State Coulumb's Law and mention its limitations.[May-2019]
12. Two infinite plane sheets of equal charge densities 1 C/m^2 are placed at (0,0,0) and (0,0,3) respectively. Find the Electric field intensity at (0,0,2).[May-2019]
13. Derive the relationship between potential and electric field intensity.
14. Define electro static field and mention any two sources. [N0v-2018]
15. Find the potential at RA = 5m with respect to RB = 15m due to point change Q = 500 μc at the original and zero reference at infinity. [N0v-2018]
16. State and explain Gauss's law.What are the limitations of gauss law. [Nov-2014][Mar-2017]
17. Describe what are the sources of electric field and magnetic field. [Dec-2014]
18. Give the relation between electric field intensity and electric flux intensity. [Nov-2015]

UNIT-I (10 Marks Questions)

1. Three equal positive charges of 4×10^{-9} coulomb each are located at three corners of a square, side 20cm. determine the electric field intensity at the vacant corner point of the square.[Nov-2018]
2. What is an electric dipole? Obtain expression for torque experienced by an electric dipole in a uniform electric field.[Nov-2018][N0v-2017][May-2019]

3. Derive the expression for the energy stored in the charged condenser. [Nov-2018][May-2019]

4. A circular disc of radius 'a' m is charged uniformly with a charge density of σ c/ m2. Find the electric field at a point 'h' m from the disc along its axis.[N0v-2017]

5. If V=2x2y+20z-(4/(x2+y2)) Volts, Find ***E*** and ***D*** at P (6,-2.5,3). [N0v-2017]

6. State and derive the expression for Equation of continuity.[May-2019]

7. Find the total charge Q with in the sphere of radius r=4 m if its volume charge density is ρv = 10/rsinθ C/m^3. [May-2019]

8. Determine the electric field intensity due to infinite line charge, at a point perpendicular to its plane and at a given distance from the line charge from first principles.[May-2018][N0v-2017]

9. Find the electric field at distance 'z' above the center of a flat circular disc of radius 'r', which carries a uniform surface charge.[May-2018][Mar-2017]

10. Derive the Relationship between electric field and electric potential.[May-2018]

11. A Charge of -0.3 μC is located at A(25, -30, 15) (in cm) and a second charge of 0.5 μC is at B(-10, 8, 12) cm. Find **E** at (i) the origin (ii) P(15, 20, 50) cm.[May-2018]

12. State and prove Gauss's law as applied to an electric field and determine the field due to an infinite line charge.[Nov-2016]

13. Derive the expression for energy stored and energy density in static electric field.[Nov-2017]

14. Four concentrated charges Q1 = 0.3 μC, Q2 = 0.2 μC, Q3 = −0.3 μC, Q4 = 0.2 μC are located at the vertices of a plane rectangle. The length of rectangle is 5 cm and breadth of the rectangle is 2 cm. Find the magnitude and direction of resultant force on Q1.[Nov-2017]

15. Define work done and electric potential. Show that the electric field intensity is negative gradient of potential.[Mar-2016]

16. Derive the expression for Potential gradient.[N0v-2018]

Fill in the Blanks:

1. Coulomb's force has the unit of _____.
2. The unit of constant of proportionality in Coulomb's law is _____.
3. The unit of line charge density is _____.
4. The unit of surface charge density is _____.
5. The unit of volume charge density is _____.
6. Electric field is defined as _____.

7. The unit of electric field is _____.

8. The unit of electric flux is _____.

Unit-II (Important points)

1. There is no electric field inside a conductor .
2. The conductor's surface is an equipotential .
3. Boundary conditions is the condition that the field must satisfy at the interface separating the media.
4. If V is the mean potential difference between the conductors, the capacitance is given by $C = \frac{Q}{V}$
5. Energy Stored in Capacitor: $W_{loss} = V.Q - \frac{1}{2}.Q.V = \frac{1}{2}.Q.V$
6. Ohm's law in point form: J=σ E
7. Continuity Equation is $\nabla.\vec{J} = -\frac{\partial \rho}{\partial t}$
8. Dielectric – dielectric boundary conditions: $E_{1t} = E_{2t}$ $D_{1n} = D_{2n}$

UNIT-II (2 Marks Questions)

1. What are Conductors and Insulators? Give examples.[Nov-2018]
2. Derive Ohm' law in point form.[Nov-2018]
3. Define current density. Write the relation between current and current density.[Nov-2017]
4. Define conduction and convection current densities. [May-2019][Nov-2016]
5. Mention the properties of a conductor.[May-2019]
6. What is meant by boundary condition? How they are useful? Explain.[May-2018]
7. State properties of conductor and dielectric materials.[May-2018]
8. What is the capacitance of a parallel plate capacitor when the stored energy is 5 μJ and the voltage across the plates is 5 V? [Nov-2017]
9. Give ohms law in point form.[Mar-2017]
10. Distinguish between conductors and dielectrics.[Mar-2016]
11. What is the capacitance of a capacitor consisting of two Parallel plates 30cm × 30cm separated by 5 mm on air.[Mar-2016]

UNIT-II(10 Marks Questions)

1. Derive Equation of continuity. What is its significance?[Nov-2018][May-2019][Mar-2016]
2. The capacitance of a parallel plate condenser is 0.2μF. Potential difference between the plates is 2V. Calculate the energy stored by the charged condenser.[Nov-2018]
3. Show the expression of the capacitance for a spherical capacitor consists of 2 concentric spheres of radius 'a'&'b' also obtain the capacitance for an isolated sphere.[Nov-2017]
4. Find the capacitance of a conducting sphere of 2 cm in diameter, covered with a layer of polyethelene with $\in r = 2.26$ and 3 cm thick.[Nov-2017]
5. Derive an expression for capacitance of co-axial cable.[Nov-2017]
6. State the boundary conditions in electrostatic fields and prove any one of them.[May-2019][Mar 2017][Mar-2016]
7. Obtain the expression for capacitance of a spherical capacitor.[May-2019]
8. Find the maximum charge that can be held on the isolated sphere 2m diameter, the sphere being in air with dielectric strength 40 kV/cm. What would be the maximum charge if this sphere were in oil of = 3.5 and dielectric strength of 75 kV/cm[May-2018]
9. Derive Poisson's and Laplace equations starting from point form of Gauss Law.[Nov-2016]
10. Establish the electrostatic boundary conditions for the tangential components of electric field and electric displacement at the boundary of two non dielectrics.[Nov-2016]
11. The relative permittivity of dielectric in a parallel plate capacitor varies linearly from 4 to 8. If the distance of separation of plates is 1 cm and area of cross-section of plates is 12 cm^2, find the capacitance. Derive the formula used.[Nov-2016]
12. Prove that the derivative of the energy stored in an electrostatic field with respect to volume is ½ D.E, where D and E electric flux density and electric field intensity respectively.[Nov-2016]
13. A parallel plate capacitor consists of two square metal plates of side 500 mm and separated by a 10 mm slab of Teflon with $\epsilon_r = 2$ and 6 mm thickness is placed on the lower plate leaving an air gap of 4mm thick between it and upper plate. If 100 V is applied across the capacitor, find D, in Teflon and air.[Nov-2017]
14. State and prove the conditions on the tangential and normal components of electric flux density and electric field intensity, at the boundary between the dielectrics.[Nov-2017]
15. Prove that the convection current density is linearly proportional to the charge density and the velocity with which the charge is transferred.[Mar-2017]
16. A parallel plate capacitor has conducting plates of area equal to 0.04m^2. The plates are separated by a dielectric material whose $\epsilon_r = 2$ with the plate separation of 1cm. Find its capacitance value.[Mar-2016]

Fill in the Blanks:

1.Potential at all the points on the surface of a conductor is_____

2.The surface charge density in a good dielectric is_____

3.If $\in r = 2$ for a dielectric medium, its electric susceptibility is_____

4.If dipole moment of 1 C-m in a dielectric material of volume 0.1 m3 exists, the polarisation is_____

5.If a potential of 1 V is applied across a capacitor of 10 PF, the energy stored is_____

6.Example of non-polar type of dielectric is_____

7..Example of polar type of dielectric is_____

Unit-III (Important points)

1.Maxwell's third equation, Curl (H)=Jc

2.Maxwell's second Equation, div(B)=0

3. Employing Biot-Savart Law, we can now express the magnetic field intensity H. In terms of these current distributions is $\vec{H} = \int_L \frac{Id\vec{l} \times \vec{R}}{4\pi R^3}$

4. the magnetic flux density related to the magnetic field intensity as $\vec{B} = \mu\vec{H}$

5. Ampere's circuital law states that the line integral of the magnetic field (circulation of H) around a closed path is the net current enclosed by this path. Mathematically, $\oint \vec{H}.d\vec{l} = I_{enc}$

6. MFI due to an infinite sheet of current and a long current carrying filament: $\vec{H} = \frac{I}{2\pi\rho}\hat{a}_\phi$

7. **MFI** due to infinitely long coaxial conductor: $H_\phi = \frac{I}{2\pi\rho}\frac{R_3^2 - \rho^2}{R_3^2 - R_2^2}$

8. Scalar Magnetic Potential $\vec{H} = -\nabla V_m$

9. Vector magnetic potential $\psi = \int_S \nabla \times \dot{A}.d\dot{s} = \oint_C \dot{A}.d\dot{l}$

10. Energy stored and density in a magnetic field $W_m = \frac{1}{2}\vec{B}.\vec{H}$

UNIT-III (2 MARKS Questions)

1. Deduce the Relation between magnetic flux, magnetic flux density.[Nov-2018]
2. Find the magnetic field intensity due to a current carrying conductor with finite length.[Nov-2018]
3. Explain Lorentz force equation.[Nov-2018][May-2019][May-2018]
4. Derive Neuman's formula for mutual inductance.[Nov-2018]
5. What is the fundamental difference between static electric and magnetic field lines?[Nov-2017]
6. A long straight wire carries a current I = 1 amp. At what distance is the magnetic field H= 1A/m. [Nov-2017]
7. A solenoid has an inductance of 20 mH. If the length of the solenoid is increased by two times and the radius is decreased to half of its original value, find the new inductance. [Nov-2017]
8. State Gauss's law for magnetostatic fields.[May-2019]
9. Prove Curl (H)=J_c
10. Write the units of magnetic scalar and vector potentials.[May-2019]
11. Explain the concept of non existence of isolated magnetic pole.[May-2018]
12. What is a magnetic dipole? How it is differ from electric dipole?[May-2018]
13. Write the expressions for Force on a straight and a long current carrying conductor in a magnetic field when the current in the conductors is in same direction and opposite directions.[May-2018]
14. Define Magnetic field intensity.[Nov-2016]
15. Write the applications of Ampere's circuital law.[Nov-2016]
16. Write the vector Poisson's equation.[Nov-2016]
17. What are the applications of permanent magnets?[Nov-2016]

UNIT-III (10 MARKS Questions)

1. Find the Magnetic Field Intensity due to a straight current carrying filament.[Nov-2018]
2. Find the magnetic field intensity at the centre O of a square loop of sides equal to 5M and carrying 10A of current.[Nov-2018][Nov-2017][May-2018]
3. Differentiate static electric and magnetic fields.[Nov-2018]
4. State Ampere's circuital law and prove the same.[Nov-2018]
5. What is scalar magnetic potential? Give its limitations.[Nov-2018][May-2019]
6. Derive an expression for magnetic field strength H, due to a current carrying conductor of finite length placed along the y-axis, at a point P in x-z plane and r distant from the origin.[Nov-2018]
7. Explain the concept self and mutual inductances[Nov-2018]

8. A toroid with cross section of radius 2cm has a silicon steel core of mean length 28cm and an air gap of length 1mm. Assume the air-gap area is 10% greater than the adjacent core and find the mmf required to establish an air-gap flux of 1.5 mwb.[Nov-2018]
9. Using Biot-Savart's law, find the magnetic field intensity on the axis of a circular loop with radius R and carrying a steady current I.[Nov-2017]
10. State Ampere's circuital law and explain any two applications of Ampere's circuital law.[Nov-2017][May-2018]
11. Derive the equation to show that curl of magnetic field intensity in equal to current density.[Nov-2017]
12. Show that the force between two parallel conductors carrying current in the same direction is attractive.[Nov-2017][May-2019]
13. Derive the expression for self inductance of a coaxial cable of inner radius 'a' and outer radius 'b'.[Nov-2017]
14. 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 and the medium is air.[Nov-2017]
15. Apply Biot-Savart's law to derive the expression for Magnetic Field Intensity due to circular loop placed on xy plane with radius 'r'.[May-2019]
16. Define Magnetic flux, Magnetic flux line and Magnetic flux density and state the relation between Magnetic flux and Magnetic flux density.[May-2019]
17. Obtain the expression for magnetic field intensity due to infinite long straight carrying a steady current I.[May-2018]

Fill in the Blanks:

1. Magnetic field is measured by _____.
2. SQUID means _____.
3. The unit of magnetic flux is _____.
4. The unit of magnetic flux density is _____.
5. Ampere's circuit law is _____.
6. Biot-Savart law is ____
7. Magnetic field is measured by _____.
8. Lorentz force equation is _____.
9. The boundary condition on H is _____.
10. The boundary condition on B is _____.

Unit-IV (Important points)

1. Maxwell's fourth equation, Curl (E)=-dB/dt
2. $\nabla \cdot \vec{D} = \rho_v$
3. Faraday's Law of electromagnetic Induction: $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
4. If a charge Q moves in a magnetic field , it experiences a force $\vec{F} = Q\vec{v} \times \vec{B}$
5. If the moving conductor is a part of the closed circuit C, the generated emf around the circuit is $\oint_c \vec{v} \times \vec{B}.d\vec{l}$ This emf is called the **motional emf**.
6. $\nabla.\nabla \times \vec{A}$ is zero for any vector
7. $.\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$
8. $\oint_c \vec{E}.d\vec{l} = -\int_s \frac{\partial \vec{B}}{\partial t}.d\vec{S}$
9. $\oint_c \vec{H}.d\vec{l} = \int_s \left(J + \frac{\partial D}{\partial t} \right).d\vec{S} = I + \int_s \frac{\partial \vec{D}}{\partial t}.d\vec{S}$
10. $\int_v \nabla.\vec{D}dv = \oint_s \vec{D}.d\vec{S} = \int_v \rho dv$

UNIT-IV (2 MARKS Questions)

1. State Faraday's law of electromagnetic induction.[Nov-2018][Mar-2017]
2. Determine the e.m.f induced about the path r=0.5, z=0, t=0. If B=0.01sin377t.[Nov-2018]
3. What is the significance of displacement current?[Nov-2017]
4. Derive Maxwell's equation derived from Ampere's law.[Nov-2017]
5. Express relation between (i)electric field intensity and magnetic field intensity for time varying field (ii) displacement current density and electric flux density.[May-2019]
6. Define statistically induced emf and dynamically induced emf.[May-2019][Nov-2016][Nov-2017]
7. Define time varying fields.[Nov-2016]
8. Write the Maxwell's equations in integral form for time varying fields.[Nov-2017]
9. What is displacement current? Explain.[Mar-2017]
10. 10. Explain how maxwell's equations are modified for time varying electric and magnetic fields.[Mar-2016]

UNIT-IV (10 MARKS Questions)

1. Write Maxwell's equation for static fields. Explain how they are modified for time varying electric and magnetic fields.[Nov-2018]
2. Generalize Ampere's law for time varying fields.[Nov-2018]
3. In a material for which $\sigma = 5.0$ s/m and $\in r = 1$, the electric field intensity is $E = 250 \sin 10^{10} t$ (V/m). Find the conduction and displacement current densities and the frequency at which they have equal magnitudes.[Nov-2018][Nov-2017][May-2019]
4. Write Maxwell's equations in integral form for time varying Fields.[Nov-2017]
5. Generalize Ampere's law for time varying fields.[Nov-2017]
6. State and explain Faraday's laws of electromagnetic induction.[Nov-2017]
7. Write Maxwell's equations for time varying fields and make their word statements.[May-2019][May-2018][Nov-2016][Nov-2017][Mar-2017]
8. Given in free space $\vec{E} = E_m \sin(\omega t - \beta z) a_y$, find $\vec{D}, \vec{B}, \vec{H}$. [May-2019]
9. State and explain Faraday's laws of electromagnetic induction with its integral and point forms.[Nov-2016]
10. Explain the concept of displacement current and obtain an expression for the Displacement current density.[May-2018][Nov-2016][Nov-2017]
11. A conductor with cross sectional area of 10 cm^2 carries a conduction current of $0.2 \sin(10^9 t)$ mA. Given that $\sigma = 2.5 \times 10^6$ S/m and $\varepsilon_r = 6$, calculate the magnitude of the displacement current density.[Nov-2017]
12. Derive Maxwell's fourth equation.[Nov-2017]

Fill in the Blanks:

1.The unit of vector magnetic potential is _____.

2. The unit of magnetic current density is _____.

3. If $E = \cos(6 \times 107t - \beta z)$ ax, β is _____.

4.Energy stored in an inductor is _____.

5. Energy stored in a magnetostatic field is _____.

Unit-V (Important points)

1. In general the wave equations can be obtained by relating the space and time variations of the electric and magnetic fields, using the Maxwell's equations.
2. The wave equation is $\nabla^2\overline{H} = \mu\sigma\frac{\partial\overline{H}}{\partial t} + \mu\varepsilon\frac{\partial^2\overline{H}}{\partial t}$
3. **Uniform Plane Wave in Free Space**

   $H_y = H_m^+ \cos(\omega t - \beta z) - H_m^- \cos(\omega t + \beta z)\ A/m$
4. **Wave Equations in Phasor Form** $\nabla^2\overline{H} = [j\omega\mu(\sigma + j\omega\varepsilon)]\overline{H}$
5. *So perfect diectric medium is also called* ***lossless dielectric.***
6. Thus for good conductor,

   $$\alpha = \sqrt{\pi f\mu\sigma}\ \ Np/m \ \text{ and}$$
   $$\beta = \sqrt{\pi f\mu\sigma}\ \ rad/m$$
7. The intrinsic impedance of a good conductor is given by

   $$\eta = \sqrt{\frac{j\omega\mu}{\sigma + j\omega\varepsilon}}$$
8. $\text{Skin depth} = \delta = \frac{1}{\alpha} = \frac{1}{\beta} = \frac{1}{\sqrt{\pi f\mu\sigma}}\ m$
9. **Poynting Vector and Poynting Theorem** $\overline{P} = \overline{E} \times \overline{H}$

Unit-V (2 Marks Questions)

1. Define Electromagnetic waves or EM waves.
2. Write the wave equations for conducting and perfect dielectrics media.
3. Write the wave equations in phasor form.
4. Define the term " uniform plane waves".
5. What are good conductors and good dielectrics?
6. Define poynting vector and poynting theorem.
7. Give the applications of poynting vector and poynting theorem.

Unit-V (10 Marks Questions)

1. State and prove poynting theorem.
2. How to convert 4-Maxwell's equations into phasor form? Explain.

3. Determine the general solution of uniform plane wave equations.
4. Derive the equation for uniform plane in free space condition.
5. Derive the wave equations for conducting medium , perfect dielectric medium and free space.
6. Describe wave propagation in good conductors and derive α, β, γ, δ and η for the same.
7. What is meant by wave propagation? Derive the expressions for α, β, γ, in a lossy dielectric medium.
8. Describe wave propagation in lossless media.
9. Describe the propagation of wave in conducting medium.

Fill in the Blanks:

1. The depth of penetration is,δ=_____
2. Total magnetic flux coming out of any closed surface is_____
3. The total power dissipated in a region can be determined using_____
4. _____ represent the wave equation for conducting medium.
5. The relationship between E and H is _____
6. The condition for good conductor is_____
7. The depth of penetration is also known as_____.