

EE6302: ELECTROMAGNETIC THEORY

(R-2013)

UNIT: I

PART A:

1. How are unit vector defined in cylindrical coordinate systems?
2. State Stoke's theorem.
3. Mention the sources of electromagnetic fields.
4. State the physical significance of curl of a vector field.
5. 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.
6. State the conditions for a vector A to be (a) solenoidal (b) irrotational
7. State divergence theorem.
8. State the vector form of electric flux density.
9. Define divergence and its physical meaning.
10. What are the different coordinate systems.
11. Mention the criteria for choosing an appropriate coordinate system for solving a field problem easily. Explain with an example.
12. When a vector field is solenoidal and irrotational.
13. Give the practical examples of diverging and curl field.
14. Obtain the unit vector in the direction from the origin towards the point P(3,-3,-2).
15. Verify that the vectors $\vec{A} = 4\vec{a}_x + 2\vec{a}_y + 2\vec{a}_z$ and $\vec{B} = -6\vec{a}_x + 3\vec{a}_y - 3\vec{a}_z$ are parallel to each other.
16. Given that $\vec{A} = 5\vec{a}_x$ and $\vec{B} = 4\vec{a}_x + 6\vec{a}_y$; find 't' such that angle between \vec{A} and \vec{B} is 45° .
17. Prove that $\text{curl grad } \phi = 0$.
18. How can a vector field be expressed as the gradient of scalar field?

19. Determine the curl of $\vec{P} = x^2yz\vec{a}_x + xz\vec{a}_z$.

20. Given that $\vec{A} = 10\vec{a}_y + 3\vec{a}_z$ and $\vec{B} = 5\vec{a}_x + 4\vec{a}_y$; find the projection of A and B.

PART B:

1. Write short notes on the following: (a) Gradient (b) Divergence (c)Curl (d) Stoke theorem.

2. Express the vector B in Cartesian and cylindrical systems. Given,

$$\vec{B} = \frac{10}{r} \vec{a}_r + r \cos \theta \vec{a}_\theta + \vec{a}_\phi$$

Then find B at (-3, 4, 0) and (5, $\pi/2$, -2)

3. i) Describe the classification of vector fields.

ii)
$$\text{If } \vec{B} = y\vec{a}_x + (x+z)\vec{a}_y$$

and a point Q is located at (-2, 6,3), express (a) the point Q in cylindrical and spherical coordinates,(b) B in spherical coordinates.

4. Determine the divergence and curl of the following vector fields:

(i)
$$\vec{P} = x^2yz\vec{a}_x + xz\vec{a}_z$$

(ii)
$$\vec{Q} = \rho \sin \varphi \vec{a}_\rho + \rho^2 z \vec{a}_\varphi + z \cos \varphi \vec{a}_z$$

(iii)
$$\vec{T} = \frac{1}{r^2} \cos \theta \vec{a}_r + r \sin \theta \cos \varphi \vec{a}_\theta + \cos \theta \vec{a}_\phi$$

5. i) Given point P(-2,6,3) and $\vec{A} = y\vec{i} + (x+z)\vec{j}$, express P and \vec{A} in cylindrical coordinates.

ii) state and prove divergence theorem.

6. i) Determine the curl of the following vector fields:

(1)
$$\vec{A} = yz\vec{a}_x + 4xy\vec{a}_y + y\vec{a}_z$$

(2)
$$\vec{B} = \rho z \sin \varphi \vec{a}_\rho + 3\rho z^2 \cos \varphi \vec{a}_\varphi$$

ii) Given that $\vec{F} = (x^2 + y^2)\vec{i} - 2xy\vec{j}$, evaluate both sides of Stoke's theorem for a rectangular path bounded by the lines $x = \pm a, y=0, z = b$.

7. i) Find the electric field at a point P(0,0,6) due to a point charge Q_1 of $0.35 \mu\text{C}$ placed at (0,5,0) and Q_2 of $-0.6 \mu\text{C}$ placed at (5,0,0).

ii) obtain in the spherical coordinate system the gradient of the function

$$f(r, \theta, \varphi) = 25r^4 \sin \theta \cos \varphi + 2 \cos \varphi + 5r \sin \varphi$$

8. i) State and derive divergence theorem.

ii) show that in cartesian coordinates for any vector \mathbf{A} , $\nabla \cdot (\nabla^2 \mathbf{A}) = \nabla^2 (\nabla \cdot \mathbf{A})$.

9. Explain the different coordinate systems.

10. Write short notes on gradient, divergence, curl and stokes theorem.

UNIT:II

PART A:

1. Define electrical potential
2. Define potential differences.
3. Name few applications of Gauss law in electrostatics.
4. State the properties of electric flux lines.
5. A dielectric slab of flat surface with relative permittivity 4 is disposed with its surface normal to a uniform field with flux density 1.5C/m^2 . The slab is uniformly polarized. Determine polarization in the slab.
6. A parallel plate capacitor has a charge of 10^{-3}C on each plate while the potential difference between the plates is 1000V . Calculate the value of capacitance.
7. Define electric dipole.
8. Define electric dipole moment.
9. Write Poisson's equation for a simple medium
10. Write Laplace equation for a simple medium.
11. Define dielectric strength.
12. What is meant by dielectric breakdown.
13. A uniform line charge with $\rho_1 = 5\ \mu\text{C/m}$ lies along the x-axis. Find \vec{E} at $(3,2,1)\text{m}$.
14. State the expression for polarization.
15. What are the boundary conditions between two dielectric media?
16. Write the continuity equation.
17. Define energy density.
18. Write the equation for capacitance of coaxial cable.
19. Write the equation for point from Ohm's law.
20. Distinguish between displacement and conduction currents.

PART B:

1. Deduce an expression for the capacitance of parallel plate capacitor having two identical media.
2. i) state and derive electric boundary condition for a dielectric to dielectric medium and a conductor to dielectric medium.
ii) Derive the expression for energy density in electrostatic fields.
3. (i) State and explain coulomb's law and deduce the vector form of force equation between two point charges.
(ii) At an interface separating dielectric 1 (ϵ_{r1}) and dielectric 2 (ϵ_{r2}) show that the tangential component of \vec{E} is continuous across the boundary, whereas the normal component of \vec{E} is discontinuous at the boundary.
4. (i) A circular disc of radius 'a' m is charged uniformly with a charge density of ρ_s C/m². Find the electric potential at a point P distant 'h' m from the disc surface along its axis.
ii) find the value of capacitance of a capacitor consisting of two parallel metal plates of 30cm x 30cm surface area, separated by 5mm in air. What is the total energy stored by capacitor is charged to a potential difference of 1000v? what is the energy density?
5. i) A circular disc of radius 'a' m is charged uniformly with a charge density of σ coulombs/m². Find the potential at a point 'h' m from the disc surface along its axis.
ii) Determine the electric field density at P(-0.2, 0, -2.3) due to a point charge of +5nC at Q(0.2, 0.1, -2.5) in air. All dimensions are in meter.
6. Find the potential at any point along the axis of a uniformly charged disc of σ C/m². The disc has radius of 'a' m
7. Derive the expression for energy stored and energy density in electrostatic fields.
8. Derive the boundary conditions at the interface of two dielectrics.
9. Point charges 1 mC and -2 mC are located at (3, 2, -1) and (-1, -1, 4) respectively. Calculate the electric force on a 10nC charge located at (0, 3, 1) and the electric field intensity at the point.
10. A linear, homogeneous, isotropic dielectric material has $\epsilon_r = 3.6$ and is covering the space between $z=0$ and $z=1$. If $v = -6000z$ volts in the material, find \vec{E}, \vec{P}, ρ_s

UNIT:III

PART A:

1. Write down the magnetic boundary conditions.
2. What is Lorentz law of force?
3. Write the expression for magnetic field H at the centre of a circular coil carrying a current of I amperes. The radius of the coil is a m
4. State ohms law for magnetic circuits.
5. Write the expression for the magnetic force between an electromagnet and an armature to be attracted.
6. Find the inductance per unit length of a long solenoid of N turns and having a length L 'mtrs'. Assume that it carries a current of I amperes.
7. State Ampere's circuital law.
8. State Biot savarts law.
9. What is the expression for inductance of a toroid?
10. Define the terms: magnetic moment and magnetic permeability.
11. State the law of conservation of magnetic flux.
12. Define magnetostatic energy density.
13. Draw the BH curve for classifying magnetic materials.
14. Define vector magnetic potential.
15. Define self inductance and mutual inductance.
16. A current of 3A flowing through an inductor of 100mH. What is the energy stored in the inductor?
17. Distinguish between diamagnetic, paramagnetic and ferromagnetic materials.
18. Sketch Gauss law for the magnetic field.
19. Classify the magnetic material.
20. State the expression for H due to infinite sheet of current.

21. Write the expression for the torque experienced by a current carrying loop placed in the magnetic field.

PART B:

1. State and explain Ampere's circuit law and show that the field strength at the end of a long solenoid is one half of that at the centre.
2. a) State and explain Bio-savarts law.
b) Derive an expression for the force between two long straight parallel current carrying conductors.
3. Derive a general expression for the magnetic flux density **B** at any point along the axis of a long solenoid. Sketch the variation of B from point to point along the axis.
4. i) For a finite current sheet of uniform current density 'k' A/m, Derive the expression for the magnetic field intensity.
ii) A coil has 1000 turns and carries a magnetic flux of 10mwb. The resistance of the coil is 4 ohm. If it is connected to a 40v DC supply estimate the energy stored in the magnetic field when the current has attained its final steady value. Derive the formula used.
5. i) Show by means of Biot Savarts law that the flux density produced by an infinitely long straight wire carrying a current I at any point distant a normal to the wire is given by $\frac{\mu_0 \mu_r I}{2\pi a}$.
ii) what is the maximum torque on a square loop of 1000 turns in a field of uniform flux density B tesla? The loop has 10cm sides and carries a current of 3A . what is the magnetic moment of the loop?
6. i) Derive Biot Savart's law and ampere law using the concept of magnetic vector potential.
ii) The core of a toroid is of 12 cm^2 area and is made of material with $\mu_r=200$. If the mean radius of the toroid is 50cm. Calculate the number of turns needed to obtain an inductance of 2.5H.
7. i) Derive the expression for the magnetic field intensity inside and outside a co-axial conductor of inner radius 'a' and outer radius 'b' and carrying a current of I amperes in the inner and outer conductor.
ii) Calculate the self inductance of infinitely long solenoid.
8. i) Derive the expression for the magnetic vector potential in the cases of an infinitely long straight conductor in free space.

ii) consider the boundary between two media. Show that the angles between the normal to the boundary and the conductivities on either side of the boundary satisfy the relation.

$$\frac{\tan \theta_1}{\tan \theta_2} = \frac{\sigma_1}{\sigma_2}$$

9. Obtain the expression for energy stored in the magnetic field and also derive the expression for magnetic energy density.
10. i) Derive the expression for coefficient of coupling in terms of mutual and self inductance of the coils
ii) An iron ring with a cross sectional area of 8cm^2 and a mean circumference of 120cm is wound with 480 turns of wire carrying a current of 2 A. the relative permeability of the ring is 1250. Calculate the flux established in the ring.
11. Derive an expression for the force between two long straight parallel current carrying conductors.

UNIT –IV

PART-A

1. State the faraday's law.
2. State the faraday's law for the moving charge in a constant magnetic field.
3. State lenz's law.
4. Define displacement current density.
5. What are electric field and the power flow in the co-axial cable?
6. Define reluctance.
7. Write the maxwell's equation from ampere's law both in integral and point forms.
8. Write down the maxwell's equation from electric gauss's law in integral and point forms.
9. Write the maxwell's equation from faraday's law both in integral and point forms.
10. Write down the maxwell's equation from magnetic gauss's law in integral and point form.
11. Write the maxwell's equations from Gauss's law in integral form.
12. Write to maxwell's equations in integral form.
13. Write down the maxwell's equations from Gauss's law in point form.

14. Write down the maxwell's equation in point form.
15. Write down the maxwell's equation in point phasor forms.
16. Write down the maxwell's equation for free space in integral form.
17. Explain why $\nabla \cdot \mathbf{B} = 0$
18. Explain why $\nabla \times \mathbf{E} = 0$
19. In material for which $\sigma = 5.0 \text{ s/m}$ and $\epsilon_r = 1$ and $\mathbf{E} = 250 \sin 10^{10} t$ (V/m) .Find the conduction and displacement current densities.
20. Explain why $\nabla \cdot \mathbf{D} = 0$.

PART – B

1. The magnetic field intensity in free space is given as $\mathbf{H} = H_0 \sin \theta \mathbf{a}_y$ A/m. Where $\theta = \omega t - \beta z$ and β is a constant quantity. Determine the displacement current density.
2. Show that the ratio of the amplitudes of the conduction current density and displacement current density is $\sigma/\omega\epsilon$, for the applied $\mathbf{E} = E_m \cos \omega t$. Assume $\mu = \mu_0$, what is the amplitude ratio, if the applied field is $\mathbf{E} = E_m e^{-t/\tau}$. where τ is real?
3. Derive maxwell's equation from ampere's law in integral and point form.
4. Do the fields $\mathbf{E} = E_m \sin x \cdot \sin t \mathbf{a}_y$ and $\mathbf{H} = (E_m/\mu_0) \cos x \cos t \mathbf{a}_z$ satisfy maxwell's equations?
5. State maxwell's equations and obtain them in differential form. Also derive them harmonically varying field.
6. State maxwell's equation and obtain them in integral and differential form.
7. Derive the maxwell's equation in phasor integral form.
8. Derive the maxwell's equation in phasor differential form.
9. If electric field intensity in free space is given by $\mathbf{E} = (50/\rho) \cos(10^8 t - 10 z) \mathbf{a}_\rho$ V/m . Find the magnetic field intensity \mathbf{H} .
10. State and derive the maxwell's equations for free space in integral form and point form for time varying field.

UNIT – V

PART –A

1. Define a wave.
2. What are wave equations for free space?
3. What is a uniform plane wave?
4. What is the relationship between E and H or brief about intrinsic impedance for a dielectric medium?
5. What are Helmholtz equations or represent equation of electromagnetic wave in the phasor form?
6. What are the wave equations for a conducting medium?
7. What is phase velocity?
8. What are the values of α, β and γ in terms of primary constants of the medium?
9. Write down the secondary constants of a good conductor.
10. Write down the values of α, β, γ velocity and intrinsic impedance for free space.
11. What is skin effect?
12. Define skin depth or depth of penetration of a conductor.
13. Determine the skin depth of copper at 60 Hz with $\sigma = 5.8 \times 10^7$ s/m. Given $\mu_r = 1$.
14. What is polarization?
15. Define linear, elliptical and circular polarization?
16. Define snell's law of refraction.
17. Define critical angle.
18. Define Brewster angle.
19. What are the standing waves?
20. How a dielectric medium can be identified as lossless and lossy for a given frequency?

PART – B

1. Derive general wave equations in phasor form and also derive for α, β, γ and η .
2. Derive wave equations for a conducting medium.
3. State pointing theorem and derive an expression for pointing theorem.
4. Explain the wave propagation in good dielectrics with necessary equations.
5. Derive the expression for total magnetic field when a vertically polarized wave is incident obliquely on a perfect conductor.
6. Determine the reflection coefficient of oblique incidence in perfect dielectric for parallel polarization.
7. Determine the reflection coefficient of oblique incidence in perfect dielectric for perpendicular polarization.
8. Define polarization. What are the different types of wave polarization? Explain them with mathematical expression.
9. Obtain the expression for the reflection coefficient and transmission coefficient for a wave normally incident on the surface of a dielectric.
10. A uniform plane wave in a medium having $\sigma = 10^{-3}$ s/m, $\epsilon = 80\epsilon_0$ and $\mu = \mu_0$ is having a frequency of 10 KHz.
 - i) Verify whether the medium is good conductor
 - ii) Calculate the following,
 - 1) Attenuation constant
 - 2) Phase constant
 - 3) Propagation constant
 - 4) Intrinsic impedance
 - 5) Wave length
 - 6) Velocity of propagation