Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Subject: ELECTROMAGNETIC Waves

QUESTION BANK

1.	Define coulomb's law of electrostatics.
2.	State divergence theorem.
3.	Define Stokes theorem.
4.	Name the universal constants in the electromagnetic model.
5.	What are surface and volume integrals?
6.	Relate the transformation between spherical and Cartesian coordinates.
7.	Summarize line, surface and volume charge density.
8.	Express the relationship between potential and electric field intensity.
9.	Outline the relationship between magnetic flux density and field density.
10.	Point out the role of vector algebra in electromagnetics.
11.	Identify the unit vector and its magnitude corresponding to the given vector $\boldsymbol{A}=5\ \mathbf{a_x} + \mathbf{a_y} + 3\ \mathbf{a_z}$.
12.	Specify the unit vector extending from the origin towards the point **G** (2, -2, -1).
13.	Justify that electric field is conservative.
14.	Analyze a differential volume element in spherical coordinates (r, θ, φ) resulting from differential charges in the orthogonal coordinate systems.
15.	What is the difference between potential and potential difference?
16.	(i) Explain in detail line, surface, and volume integral of vector function. (ii) Express the rate of change of a scalar in a given direction in terms of its gradient and its properties.
17.	Mention the two sources of electromagnetic fields.
18.	How would you relate the electric field intensity and electric flux density?
19.	(i)Write short notes on scalar and vector field. (ii) What is unit vector? Discuss on the mathematical operations with vector.

20.	Give examples for uniform and non-uniform electric fields.
21.	Summarize the principle of Superposition as applied to an electric potential of a point.
22.	State Gauss law.
23.	Describe about capacitance and capacitors.
24.	Calculate the values of ***D*** at a distance r = 5m for the uniformly charged sphere of radius 2m with charge density of 20 nC/m^3.
25.	Solve the energy stored in a 10 µF capacitor which has been charged to a voltage of 400V.
26.	How do you find the equivalent capacitance of two capacitors C_1 and C_2 connected in series?
27.	Obtain the relation between current and current density.
28.	Identify equation of Ohm's law in point form.
29.	Compare Poisson's and Laplace's equation.
30.	Evaluate the unique solution of electrostatic fields.
31.	Calculate the value of capacitance between two square plates having cross sectional area of 1 sq.cm separated by 1 cm placed in a liquid whose dielectric constant is 6 and the relative permittivity of free space is 8.854 pF/m.
32.	Formulate the current density of copper wire having conductivity of 5.8 $*10^7$ S/m and magnitude of electric field intensity **E** is 20V/m.
33.	Generalize the continuity equation in integral and differential form.
34.	Q_1 and Q_2 are the point charges located at (0,-4, 3) and (0, 1, 1).If Q1 is 2 nC, Find Q2 such that the force on test charge at (0,-3,4) has no z component.
35.	i)State and explain coulomb's law and deduce the vector form of force equation between the two-point charges. ii) Write notes on principle of Superposition as applied to charge distribution.
36.	(i) State and prove Gauss law. (ii) Obtain the point form of gauss law.
37.	(i) Write the equation of continuity in integral and differential form. (ii) Discuss the point form of ohm's law and obtain the expression for resistance of a conductor.
38.	Mention the importance of Poisson's and Laplace's equation in electromagnetics with necessary equations.
39.	Explain any two applications of Gauss law with neat diagrams.
40.	Obtain the expression for potential due to an electric dipole at any point P. Also find the electric field intensity and in terms of dipole moment.
41.	Develop the boundary conditions of the normal and tangential components of electric field at the interface of two media with different dielectrics.

Q.No	Unit -2 Questions
1.	Define magnetic field and magnetic lines of force.
2.	State Biot-Savart's law.
3.	How would you describe Ampere's circuital law?
4.	What is scalar magnetic potential?
5.	Write about magnetic flux and flux density.
6.	List the applications of Ampere's circuital law.
7.	Point out the relation between magnetic flux density and magnetic field intensity.
8.	State the concept of permeability and its unit.
9.	Write the Lorentz force equation for a moving charge?
10.	the expression for magnetic moment.
11.	Identify the relationship between magnetic field intensity and magnetization.
12.	Classify the different types of magnetic materials.
13.	Identify the expression of force between two current elements.
14.	Express the self and mutual inductance.
15.	Examine the expression of energy stored in an inductor.
16.	Analyze the mutual inductance of two inductively tightly coupled coils with self-inductance of 25mH and 100mH.
17.	Find the energy stored in inductor having current of 3A flowing through the inductor of 100mH.
18.	Compute torque where magnetic field is $\mathbf{B}=0.2\ \hat{\mathbf{a}}_x + 0.4\ \hat{\mathbf{a}}_z$ Wb/m^2 and magnetic dipole moment is $\mathbf{M}=8*10^{-3}\ \hat{\mathbf{a}}_z$ Am^2.
19.	Generalize the phenomenon of hysteresis with reference to ferromagnetic materials.
20.	Express the energy stored in a magnetic field in terms of field quantities.
21.	From the Biot-Savart's law, write the expression for magnetic field intensity at a point P and distance R from the infinitely long straight current carrying conductor. (13)
22.	Derive the equations for magnetic field intensity and magnetic flux density at the center of the square current loop using Biot-Savart's law.
23.	Write short notes on i) Magnetic field due to current carrying conductors. ii) Law of non-magnetic monopoles.
24.	State about magnetization. Describe the classification of magnetic materials with examples**.**

25.	Determine the magnetic field intensity at the origin due to current element $Idl = 3\pi(\hat{\mathbf{a}}_x + 2\,\hat{\mathbf{a}}_y + 3\hat{\mathbf{a}}_z)$ μA · m at (3,4,5)m in free space.
26.	(i) Discuss about the force on a straight and long current carrying conductor placed in the uniform magnetic field. (ii) Explain with neat diagram about magnetic torque.
27.	(i) Using Biot-Savart's law, derive the magnetic field intensity on the axis of a circular loop of radius R carrying a steady current I. ii) A circular loop located on $x^2 + y^2 = 9$, $z = 0$ carries a direct current of 10 A along $\mathbf{a}_\varphi$. Calculate **H** at (0, 0, 4) and (0, 0, -4).
28.	Determine the expression for Ampere circuital law. Apply the law for any two applications with necessary illustrations.
29.	i) Write the expression for Maxwell's curl equation for magnetic field from Ampere circuital law. ii)Solve the magnetic field at a point P (0.01, 0, 0) m if current through a co- axial cable is 6 A. which is along the z-axis and a=3mm, b=9mm, c=11mm.
30.	Let **A**=(3y-z) $\mathbf{a_x}$+2xz$\mathbf{a_y}$ Wb/m in a region of free space. i)Prove that $\nabla.\boldsymbol{A} = 0$ ii)At P (2, -1,3) find **A, B, H** and **J**
31.	i) Estimate the expression for inductance of a toroidal coil carrying current I, with N turns and the radius of toroid 'r'. ii) Formulate the expression for inductance of a coaxial cable.
32.	Examine the magnetic field intensity within a magnetic material where i) M=150A/m and $\mu=1.5\times10^{-5}$ H/m ii)**B**=300μT and χ_m=15.
33.	Describe about the magnetic boundary condition at the interface between two magnetic medium and derive the necessary boundary conditions.
34.	A solenoid with N_1=2000, r_1=2 cm and l_1= 100cm is concentric within a second coil of N_2= 4000, r_2= 4cm and l_2=100cm.Calculate mutual inductance assuming free space conditions.
35.	i) Distinguish between magnetic scalar potential from the vector potential with necessary equations. (8) ii) Calculate the magnetic flux density for a current distribution in free space, **A**= $(2x^2y+yz)\,\hat{\mathbf{a}}_x + (xy^2-xz^3)\,\hat{\mathbf{a}}_y-(6xyz-2x^2y^2)\,\hat{\mathbf{a}}_z$ Wb/m.
36.	(i) A solenoid is 50 cm long, 2 cm in diameter and contains 1500 turns. The cylindrical core has a diameter of 2 cm and a relative permeability of 75. This coil is co-axial with second solenoid which is 50 cm long, 3 cm diameter and 1200 turns. Solve the inductance L for inner and outer solenoid. (ii) Propose the solution for energy stored in the solenoid having 2m long and 10 cm in diameter and is wound with 4000 turns of wire, carrying a current of 8 A.

UNIT IV TIME-VARYING FIELDS AND MAXWELL's EQUATIONS	
Faraday's law, Displacement current, Gauss's law for magnetic field, Maxwell's four equations in integral and differential form, Potential functions, Electromagnetic boundary conditions, Wave equations and solutions, Time- harmonic fields, Electromagnetic power flow and Poynting vector.	
1	State Lenz's law.
2	List out the characteristics medium in which EMF exist.
3	Write the Maxwell's expression for free space.
4	Point out the Maxwell's equation derived from faraday's law.
5	Define Poynting theorem.
6	Express phase velocity with necessary equation.
7	Obtain the expression for induced emf when a moving closed path is placed in a time varying magnetic field.
8	Summarize the differential form of Maxwell's Equation.
9	What is the difference between conduction current and displacement current?
10	Illustrate the Maxwell's equation for a good conductor.
11	Summarize the expression for Maxwell's equation in integral form.
12	Mention the significance on displacement current.
13	Identify the relationship between average power density and amplitude of electric field.
14	Analyze on the materials in which both conduction and displacement current exist.
15	Write the phenomenon of electromagnetic induction.
16	Based on the magnitudes of current densities how to categorize conductor and dielectric materials?
17	What is the significance of ratio of conduction current density and displacement current density.
18	Evaluate the modification in the equation of continuity due to inconsistency of ampere circuital law.

19	Obtain the retarded electric scalar potential and retarded magnetic vector potential.
20	Express Poynting theorem in point form and integral form.
21	i) Electric flux density in a charge free region is given by $D=10xa_x+5ya_y+kza_z \mu C/m^2$. Find the constant k. ii) If the magnetic field H= $(3x\cos\beta+6y\sin\alpha)\ a_z$, Determine the current density **J** if fields are invariant with time.
22	A circular loop of N turns of conducting wire lies in the XY plane with its center at the origin of magnetic field specified by B= $B_0 \cos(\pi r/2b) * \sin \omega t\ a_z$ where, b is the radius of the loop and ω is the angular frequency. Find the emf induced in the loop.

23	(i) Obtain the Maxwell's equation for harmonically varying fields. (ii) In a given lossy dielectric medium, conduction current density $\mathbf{J}_c$=0.02 sin10^9t (A/m^2). Find the displacement current density if $\sigma=10^3$ S/m and ε_r=6.5
24	Derive the Maxwell's equation for a time varying are modified for time varying from fundamental laws of electric and magnetic fields.
25	Explain in detail on retarded scalar and vector potential and derive the generalized wave equation in free space.
26	Illustrate the integral and point form of Maxwell's equations for static fields.
27	i) Find the transformer EMF induced in a stationary closed path in a time varying B field? ii)Obtain the motional EMF induced in moving closed path in static B field.
28	Calculate the maximum emf induced in a coil of 4000 turns of radius of 12 cm rotating at 30rps in a magnetic field of 0.05 Wb/m^2.
29	i) Deduce the detailed steps for the derivation of electromagnetic boundary conditions for a time varying fields. ii) Determine EMF induced about the path r = 0.5,z = 0, t = 0. If **B** = 0.01sin377t
30	i)Illustrate with necessary fundamentals the equation of continuity of current in differential form. ii) Prove that modified ampere's law is consistent with the time varying field.
31	Analyze the physical interpretation of Maxwell's first and second equations.
32	In a region where $\varepsilon_r = \mu_r = 1$ and σ=0 let **A**=10^{-3} y cos3*10^8 t cosz a_z Wb/m and V=3*10^5 y sin 3*10^8 t sinz V. Find **E** and **H.**

33	Derive an expression for displacement current density and state the physical significance of it.
34	Do the fields E=E_m sinx sint a_y and H= (H_m /μ_0) cosx cost a_z satisfy Maxwell's equations?
35	In free space, E= 50 cos (ωt- βz) $\hat{a}_x$ V/m. Find the average power crossing a circular area of radius 2.5 m in the plane Z=0. Assume $E_m = H_m \cdot \eta_0$ and η_0 =120$\pi\Omega$.
36	The unit vector 0.48 $\hat{a}_x$ – 0.6 $\hat{a}_y$ + 0.64 $\hat{a}_z$ is directed from region 2 (ε_{r2} = 2.5 , μ_{r2} =2 , σ_2 = 0) towards region 1 (ε_{r1} = 4 , μ_{r1} =10 , σ_1 = 0).If H1= (-100 $\hat{a}_x$ – 50 $\hat{a}_y$ + 200 $\hat{a}_z$) sin 400t A/m at the point p in region 1 adjacent to the boundary. Determine the amplitude at point P of : a) HN_1 b) H_{tan1} c) H_{N2} d) H_2

37	Calculate β and **H** in a medium characterized by σ=0, μ= μ_0, Ɛ=4 ε_0 and **E**=20 sin (10^8t-βz)a_y V/m.
38	Solve the value of k such that following pairs of field satisfies Maxwell's equation in the region where σ=0, σ_v=0 (i) **E** =[kx-100t] a_y V/m, **H**=[x+20t] a_z A/m and μ=0.25H/m, ε=0.01F/m (ii) **D**=5xa_x-2a_y+kza_z μC/m^2, **B**=2a_y mT and μ=μ_0, ε=ε_0.
Unit - PLANE ELECTROMAGNETIC WAVES	
Uniform Plane waves in lossless media, Plane waves in lossy media (low-loss dielectrics and good conductors), Group velocity, Normal incidence at a plane conducting boundary, Normal incidence at a plane dielectric boundary.	
1	Illustrate the reflection coefficient of normal incidence at a plane dielectric boundary.
2	Define Group velocity.
3	Describe the characteristics of uniform plane wave?
4	State depth of penetration.
5	Give the expressions for propagation constant, intrinsic impedance if a wave propagates in a lossy dielectric.
6	Mention the significance of loss tangent.
7	Write the intrinsic impedance of free space.
8	Point out the difference between attenuation constant and phase constant.
9	State the general wave equation in terms of electric and magnetic fields.
10	Illustrate the cross product of E and H in uniform Plane waves
11	Calculate the velocity of a plane wave in a lossless medium having a relative permittivity of 4 and a relative permeability of 1.2.

12	Find the characteristics impedance of the medium whose relative permittivity and relative permeability is 1.
13	Derive the expression for transmission and reflection coefficient for normal incidence at plane conducting boundary.
14	Express the values of skin depth for a plane wave propagating through the dielectric with attenuation constant of 0.2887 Np/m.
15	Examine the significance of intrinsic impedance.
16	Analyze the wave equation in phasor form.
17	Formulate the expression for the intrinsic impedance, attenuation constant and phase constant for good conducting medium.
18	Can a magnetic field exist in a good conductor if it is static or time varying? Explain.
19	Compute propagation constant in free space for a wave with 100MHz.
20	Develop the expressions for Standing wave ratio when the amplitudes of reflected and incident waves are equal.
21	Starting from the Maxwell's equation derive homogenous vector Helmholtz's equation in phasor form.

22	Derive the wave equation for the electric and magnetic fields for free space conditions.
23	Write short notes on uniform plane waves and derive the wave equation.
24	Describe the intrinsic impedance of uniform, plane waves in lossy dielectric and lossy conductor.
25	A uniform plane wave $E_y = 10 \sin(2\pi * 10^{8t} - \beta x)\, \hat{a}_y$ is travelling in x directon in free space. Determine i) Phase constant ii) Phase velocity iii) Expression for H_z. Assume $E_z = 0 = H_y$.
26	Explain the condition under which the magnitude of the reflection coefficient equals that of the transmission coefficient for a uniform wave at normal incidence on an interface between two lossless dielectric medium.
27	Demonstrate the equations for a plane wave incident normally on a plane dielectric boundary.
28	E and H waves travelling in free space are normally incident on the interface with a perfect dielectric with $\varepsilon_r = 3$. Compute the magnitudes of incident, reflected and transmitted E and H waves at the interface.
29	A 300 MHz uniform Plane propagates through fresh water for which $\varepsilon_r = 78$, $\mu_r = 1$ and $\sigma = 0$. Calculate attenuation constant, Phase Constant, Wavelength, Intrinsic impedance.
30	Determine the intrinsic impedance, wavelength, attenuation, phase, and propagation constant for electromagnetic waves in any medium.
31	Derive the electromagnetic wave equation in phasor form with necessary equations.

33	Examine the expressions for the transmission and reflection coefficients at the interface of two media for normal incidence.
34	Estimate the frequency of a wave and the conductivity of the medium for a uniform plane wave travelling at a velocity of $2.5*10^5$ m/s having a wavelength of 0.25 mm in a non-magnetic good conductor.
35	A 6580 MHz uniform plane is propagating in a material medium of $\varepsilon_r = 2.25$. If the amplitude of electric field intensity of a lossless medium is 500 V/m. Calculate the phase constant, Propagation constant, velocity, wavelength and intrinsic impedance. Also find the amplitude of magnetic field intensity.
36	(i) Estimate α, β and the wavelength of a material for a 9 GHz wave propagating through a material that has a dielectric constant of 2.4 and loss tangent of 0.005. (ii) Calculate the skin depth for a medium with conductivity 100 ℧/m, relative permeability of 2 and relative permittivity of 3 at 1 GHz.
37	Evaluate the amplitudes of reflected and transmitted fields (electric and magnetic both) at the interface of two regions, if $\mathbf{E_i}$ = 1.5 mV/m in region 1 for which ε_{r1} = 8.5, μ_r = 1 and σ =0 and region 2 is a free space.
38	(i) Calculate the skin depth and wave velocity at 2 MHz in aluminum with conductivity 40 MS/m and μ_r = 1. (ii) A plane wave propagating in free space has a peak electric field of 750mV/m. Estimate the average power through a square area of 12cm on a side perpendicular to the direction of propagation.