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AN AUTONOMOUS INSTITUTION
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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

23ECT202 - ELECTROMAGNETIC FIELDS AND WAVES

CLASS/SEM: II ECE/IV SEM

UNIT II – ELECTROSTATICS

Part A - Two Marks

1. State Gauss's Law.

The electric flux passing through any closed surface is equal to the total charge enclosed by that surface.

2. State the application of Gauss's law.

1) The Gauss's law can be used to find *E* and *D* for symmetrical charge distributions.

2) It is used to find the charge enclosed or the flux passing through the closed surface.

3. What is an equipotential surface?

An equipotential surface is an imaginary surface in an electric field of a given charge distribution, in which all points on the surface are at the same electric potential.

4. Define the unit of Potential difference.

The unit of potential difference is Volt. One Volt potential difference is one Joule of work done in moving unit charge from one point to other in the field.

5. Define potential difference.

The work done per unit charge in moving unit charge from B to A in the field *E* is called potential difference between the points B to A.

6. Define relaxation time.

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

7. What is Potential Gradient?

The rate of change of potential with respect to the distance is called potential gradient.

8. What is Gaussian surface? What are the conditions to be satisfied in special Gaussian surface?

The surface over which is the Gauss's law is applied is called Gaussian surface. Obviously such a surface is a closed surface and it has to satisfy the following conditions.

1) The surface may be irregular but should be sufficiently large so as to enclose the entire charge.

2) The surface must be closed.

3) At each point of the surface *D* is either normal or tangential to the surface.

4) The electric flux density D is constant over the surface at which *D* is normal

9. Why is the electric field the negative gradient of potential?

The electric field (E) is the negative gradient of the electric potential (V) because it represents the direction and rate of maximum decrease of potential in space. Mathematically, this is expressed as:T

10. Define Absolute potential.

The work done in moving a unit charge from infinity (or from reference point at which potential is zero) to the point under the consideration against *E* is called absolute potential of that point.

11. What is Polarization?

The applied field *E* shifts the charges inside the dielectric to induce the electric dipoles. This process is called Polarization.

12. What is Polarization of Dielectrics?

Polarization of dielectric means, when an electron cloud has a centre separated from the nucleus. This forms an electric dipole. The dipole gets aligned with the applied field.

13. What is method of images?

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

14. When is method of images used?

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

15.Define energy density in an electric field.

The energy density in an electric field refers to the amount of electrostatic energy stored per unit volume in a given region of space due to the presence of an electric field. It represents the potential energy stored in the system as a result of the work done in establishing the field.

16. Write the expression for electrostatic energy density.

$$u_E = \frac{1}{2}\epsilon E^2$$

uE = energy density (J/m³)

ϵ\epsilonϵ = permittivity of the medium (F/m)

E = magnitude of the electric field (V/m)

17.What is displacement current?

Displacement current is a time-varying electric field that produces a current-like effect in regions where no actual charge carriers (conduction current) exist.

18.What is conduction current?

Conduction current is the flow of actual charge carriers (such as electrons in metals or ions in solutions) due to an applied electric field. It follows Ohm’s law,

19.Write the equation for displacement current density.

$$J_d = \epsilon \frac{\partial E}{\partial t}$$

20. State Poisson’s equation in electrostatics.

Poisson’s equation describes the relationship between the electric potential V and the charge density ρv in a given region. It is derived from Gauss’s law

21.What is Laplace’s equation?

Laplace’s equation is a special case of Poisson’s equation when the charge density is zero (ρ_v=0).

22.How does Laplace’s equation differ from Poisson’s equation?

Feature	Poisson's Equation	Laplace's Equation
Equation	$\nabla^2 V = -\frac{\rho_v}{\epsilon}$	$\nabla^2 V = 0$
Charge Density (ρ_v)	Non-zero	Zero
Application	Used in regions with charge	Used in charge-free regions
Examples	Inside a charged conductor, inside a capacitor with charge	Inside a hollow conductor, free space between plates of a capacitor

Poisson's equation is useful for solving electrostatic problems with charge distributions, while Laplace's equation is mainly used for potential calculations in charge-free regions, such as in boundary value problems in electrostatics.

23.Define Capacitance

Capacitance is the ability of a conductor to store electric charge when a potential difference is applied across it. It is defined as the ratio of the charge stored (Q) on the conductor to the applied voltage (V) across it.

C=QV

Part B - Sixteen Marks

1. State and prove Gausss's Law.

2. Apply Gauss's law and derive an expression for the total charge enclosed and electric flux density within a uniformly charged sphere of radius R, having a uniform volume charge density ρv C/m3 Determine the expression for the following regions: i) Inside the sphere ii) Outside the sphere

3. Derive an expression for the electric flux density *D* in the region surrounding and between two concentric spherical shells. Use Gauss's Law to determine the flux density at regions $(i)\, r < a\ (ii)\, a < r < b\ (iii)\, r > b > a\ (iv)\, r = a\ (v)\, r = b$

4. Analyze and derive the conditions governing the behavior of electric field intensity E and electric flux density D at the interface between two different dielectric materials with permittivities ϵ_1 and ϵ_2.

5. State and derive electric boundary condition for a dielectric to dielectric medium

6. Derive an expression for the capacitance of a parallel plate capacitor having two dielectric media.

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

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

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

10.Briefly explain about the wave incident

(i) Normally on perfect conductor

(ii) Obliquely to the surface of perfect conductor.

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

12. Derive the Laplace's and Poisson's equations from Gauss's law for a linear material medium. State importance of these equations.

13.Two Concentric Shells are placed in free space with $\rho = 5$ C/m² at R = 2 m, $\rho = -2$ C/m² at R = 4 m. Determine the flux density at R = 1, 4.5 and analyze the effect of flux variations at different distances.