UNIT-II ELECTROSTATICS II

PART – A

1. **Define Electric field intensity or Electric field.**

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

$$\vec{E} = \frac{\vec{F}}{Q}$$

2. **What is the practical significance of dielectric strength?**

The minimum value of the applied electric field at which the dielectric breakdown occurs is Called dielectric strength.

3. **What is an Electric dipole?**

Dipole or Electric dipole is nothing but two equal and opposite point charges are separated by a very small distance.

4. **Define polarization**

Polarization is defined as dipole moment per unit volume

5. **State Coulomb's Law**

The force between two part charges is proportional to the product of charges and is inversely proportional to the square of distance between them.

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{R^2}$$

6. **Write down the expressions for Laplace's and Poisson's equations**

Poisson's equations :

$$\nabla \cdot \nabla V = \nabla^2 V = -\frac{\rho_v}{\varepsilon}$$

Laplace's equations

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial x^2} = -\frac{\rho_v}{\varepsilon}$$

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

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

7. State the vector form of electric flux density

The electric flux density is defined as electric flux per unit area. It is denoted by D

D=Q/A (c/m2)

the flux density vector is defined as:

$$\vec{D} = \varepsilon \vec{E}$$

8. Write the capacitance in a coaxial cable?

$$C = \frac{2® £_0 £_r}{\ln(b/a)} \quad \textbf{F/m}$$

9. A uniform line charge with P_L = 5 «c/m lies along the x-axis. Find $\bar{E}$ at (3,2,1)m.

Given data: $P_L = 5$ «c/m r = (3,2,1)m

Find: $\bar{E}$ (Electric field intensity) = ?

Formula: $E = \frac{°_l}{2® £_0 r}$

Solution:

$$E = \frac{5 \times 10^{-6}}{2 \times ® \times \frac{1}{36 \times ® \times 10^9} \times \sqrt{14}} = 24.05 \times 10^3 \text{ (V/m)}$$

10. What is the significance physical difference between Poisson's and Laplace's equation?

Poisson's and Laplace equation are useful for determining the electrostatic potential V in regions at whose boundaries are known.

When the region of interest contains charges in a known distribution $°_v$ Poisson's equation can be used to determine the potential function.

11. The electrical potential near the origin of a system of co-ordinates is V=ax^2+by^2+cz^2.Find the field at (2,4,6).

Given data: V=ax^2+by^2+cz^2 (x,y,z) = (2,4,6)

Find : Field (E) = ?

Formula: E = –∇V

Solution:

$$\nabla V = \frac{\partial V}{\partial x}\bar{a}_x + \frac{\partial V}{\partial y}\bar{a}_y + \frac{\partial V}{\partial z}\bar{a}_z = 2ax\,\bar{a}_x + 2by\,\bar{a}_y + 2cz\,\bar{a}_z$$

$$E = -\nabla V = -(2ax\,\bar{a}_x + 2by\,\bar{a}_y + 2cz\,\bar{a}_z)$$

At (2,4,6) $E = -(2a\,\bar{a}_x + 4b\,\bar{a}_y + 6c\,\bar{a}_z)$ V/m.

12. Write the poisson's & laplace's equations.

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

Where

V is the potential

ρ_v is the volume charge density

ε is the dielectric constant or permittivity of the medium.

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

13. Write down the magnetic boundary conditions.

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

ii) The tangential components of field intensity H is continuous across the boundary

14. Define potential

Potential at any point is defined as the workdone is moving a unit positive charge from infinity to that point in an electric field.

$$V = \frac{Q}{4\pi\varepsilon r}$$

15. Define capacitance

It is defined as the ratio of magnitude of charge on either of the conductor to the potential difference between conductors. It is given by

$$C = \frac{Q}{V}$$

16. Describe what are the sources of electric field and magnetic fields.

Stationary charges produce electric field that are constant in time: hence the term electrostatics. Moving charges (steady currents) produce magnetic fields that are constant in time; hence the term magnetostatics.

17. If $V = \frac{20}{x^2 + y^2}$ **find E and D**

Given data: $V = \frac{20}{x^2 + y^2}$

Find : E & D = ?

Formula:

$E = -\nabla V \qquad D = \text{£} E$

Solution:

$$\nabla V = \frac{\partial V}{\partial x}\bar{a}_x + \frac{\partial V}{\partial y}\bar{a}_y + \frac{\partial V}{\partial z}\bar{a}_z$$

$$E = -20\left[\frac{\partial}{\partial x}(x^2 + y^2)^{-1} + \frac{\partial}{\partial y}(x^2 + y^2)^{-1} + \frac{\partial}{\partial z}(x^2 + y^2)^{-1}\right] = 40\left[\frac{x}{(x^2 + y^2)^2} + \frac{y}{(x^2 + y^2)^2}\right]$$

$$D = 40\text{£}\left[\frac{x}{(x^2 + y^2)^2} + \frac{y}{(x^2 + y^2)^2}\right]$$

18. Name a few applications of Gauss's Law in electrostatics.

Gauss's Law is applied to determine the electric field intensity from a closed surface.(e.g) Electric field can be determine for shell, two concentric shell or cylinders, etc.

20. What is the use of Gauss's Law?

Gauss's law is particularly useful in determining the electric field E of a charge distribution with some symmetry condition.

PART – B

1) (a) A total charge of 10^{-8} C is distributed uniformly along a ring of radius of 5m. Calculated the potential on the axis of the ring at a point 5m from the centre of the ring.

(b) Conducting spherical shells with radii a=10cm and b=30cm are maintained at a potential difference of 100V such that V (r=b) = 0 and V (r=b) = 100 volts. Determine V and $\bar{E}$ in the region between the shells.

2) **(a)** Point charges 1mC and -2mC 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 that point.

(b) A dielectric sphere (£_r =5.7) of radius 10cm has a point charge 2PC placed at its center.

Calculate:

(i) The surface density of polarization charge on the surface of the sphere

(ii) The force exerted by the charge on a -4 Pc point charge placed on the sphere.

3) (a) Derive the boundary conditions at the charge interface of two dielectric media.
   (b) State and prove Gauss's Law
4) Discuss Electric field in free space, dielectric and in conductors.
5) Conducting spherical shells with radii a=10cm and b=30cm are maintained at a potential difference of 100v such that V(r=b)=0 and V(r=a)=100volts. Determine 'v' and 'E' in the rejoin between the shells.
6) Determine the capacitance of a capacitor consisting of two parallel metal plates 30cm x 30cm surface area separated by 5mm in air. What is the total energy stored by the capacitor if the capacitor is charged to a potential difference of 500v?
7) What is dipole moment? Obtain expression for the potential and field due to an electric dipole.Two point charges Q_1 = 4nC_1, Q = 2nC are kept at (2, 0, 0) and (6, 0, 0). Express the electric field at (4, -1, 2)

8. Derive expression for potential due to a dipole.
9. Derive expression for energy and energy density in a electric field.
10. Derive an expression for capacitance between two parallel wires.
11. Derive the electric boundary conditions.