College: Marwari College, Darbhanga

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Year: D-I

Paper: II

Group: B

Topic: (1) Poisson's and Laplace's equation (2) Superposition principle

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Poisson's and Laplace's equation

In the section of "Electric potential" we found that the electric field can be written as the gradient of a scalar potential:

$$\vec{E} = -\nabla V \qquad \text{——— (1)}$$

for the behavior of electrostatic field, the fundmental eqs. for $\vec{E}$,

Monday 24

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0} \qquad \text{——— (2)}$$

$$\vec{\nabla} \times \vec{E} = 0 \qquad \text{——— (3)}$$

Using eq^n (1) and (2), we get

$$\boxed{\nabla^2 V = -\frac{\rho}{\epsilon_0}} \qquad \text{——— (4)}$$

This eq^n is known as Poisson's eq^n.

In regions where there is no charge density or in charge free space, eqn (4) becomes,

$$\nabla^2 V = 0 \quad \text{——— (5)}$$

which is Laplace's equation.

Superposition principle

(i) The principle of superposition of forces in electrostatics states that when a number of charges are interacting, the electrostatic force between two charges is not affected by the existence of the other charges and the total electrostatic force on a charge is the vector sum of all the forces due to other charges.

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \cdots$$

26 Wednesday

(ii) The principle of superposition states that every charge in space creates an electric field at point independent of the presence of other charges in that medium. The resultant electric field is a vector sum of the electric field due to individual charges.

$$\vec{E} = \vec{E_1} + \vec{E_2} + \vec{E_3} + \dots$$