

Question:

What happens to Maxwell's equations under static conditions?

Answer:

Step 1

Under static conditions, the volume charge density (ρ_v) and magnetic flux density (\mathbf{B}) are constant in time. Therefore, the time derivatives of \mathbf{B} and \mathbf{D} vanishes.

Therefore, the Maxwell's equations in electrostatics become:

$$\nabla \cdot \mathbf{D} = \rho_v$$

$$\nabla \times \mathbf{E} = 0$$

Step 2

Under static conditions, none of the parameters in Maxwell's equations are time-dependent. That is, it is time-independent.

Thus, Maxwell's equations under static conditions are **time-independent**.

Question:

How is the current density \mathbf{J} related to the volume charge density ρ_v ?

Answer:

Step 1

Current density \mathbf{J} and volume charge density ρ_v are related by the expression:

$$\mathbf{J} = \rho_v \mathbf{u} \text{ A/m}^2$$

Where

Charge velocity is \mathbf{u}

Question:

What is the difference between convection and conduction currents?

Answer:

Step 1

Convection currents are due to the actual movement of electrically charged matter, while conduction currents occur when electrons move from atom to atom.

Question:

When characterizing the electrical permittivity of a material, what do the terms linear and isotropic mean?

Answer:

Step 1

When characterizing the electrical permittivity of a material, the word *linear* refers to when the permittivity ϵ is independent of the magnitude of the electric field E . *Isotropic* refers to when the permittivity is independent of the direction of the electric field.

Question:

If the electric field is zero at a given point in space, does this imply the absence of electric charges?

Answer:

Step 1

The field at a point is the superposition of the field from each particle. So, if the contributions from more than one particle add up to zero at a point; then, there can be zero field in the presence of electric charges.

Step 2

That is, if the electric field is zero at a point in space, this does not imply the absence of electric charges.

Question:

State the principle of linear superposition as it applies to the electric field due to a distribution of electric charge.

Answer:

Step 1

The principle of linear superposition due to a distribution of electric charge states that the total electric field of a distribution of charges with volume charge density ρ_v at a point P is given by integrating the fields due to each differential charge over the volume V' .

$$E = \int_{V'} dE$$

Or

$$E = \frac{1}{4\pi\epsilon} \int_{V'} \hat{R}' \frac{\rho_v dV'}{R'^2}$$

Question:

Explain Gauss's law. Under what circumstances is it useful?

Answer:

Step 1

Gauss's law states that the total electric field flux through a closed surface integrated over the surface is equal to the total charge enclosed by the surface.

Gauss's law is a useful way to determine the flux density when a charge distribution has symmetry that allows for an uncomplicated integration of flux density over an appropriate Gaussian surface.

Question:

How should one choose a Gaussian surface?

Answer:

Step 1

Gaussian surfaces should be chosen so that, from symmetry considerations, the flux density is constant in magnitude and either completely normal to or completely tangential to the surface across each subsurface of the Gaussian surface S .

Question:

What is a conservative field?

Answer:

Step 1

Write the expression of the Stoke's theorem for a vector field.

$$\oint_L \mathbf{E} \cdot d\mathbf{l} = \int_S (\nabla \times \mathbf{E}) \cdot d\mathbf{s}$$

Step 2

A vector field, whose curl is equal to zero, is a conservative field.

(or)

A vector field, with line integration along a closed path is zero, is a conservative field.

Step 3

That is,

$$\oint_L \mathbf{E} \cdot d\mathbf{l} = \int_S (\nabla \times \mathbf{E}) \cdot d\mathbf{s} = 0$$

Then the vector field \mathbf{E} is **conservative** or an **irrotational** field.

Question:

Why is the electric potential at a point in space always defined relative to the potential at some reference point?

Answer:

Step 1

The electric potential at a point in space is always defined relative to the potential at some reference point because there is no such thing as an absolute voltage; the electric potential is relative to some reference.

Question:

Explain why Eq. is a mathematical statement of Kirchhoff's voltage law.

Equation

$$\oint_C \mathbf{E} \cdot d\mathbf{l} = 0 \quad (\text{Electrostatics}). \quad (4.40)$$

Answer:

Step 1

$$\oint_C \mathbf{E} \cdot d\mathbf{l} = 0$$

The expression $\oint_C \mathbf{E} \cdot d\mathbf{l} = 0$ is a mathematical representation of Kirchhoff's voltage law. Because, the line integral of electric field is electric potential, and this says that the integral of electric field over a closed loop is zero, meaning that the voltage around a loop is zero. Kirchhoff's law says that all voltages around a circuit sum to zero.

$$\oint_C \mathbf{E} \cdot d\mathbf{l} = 0$$

Therefore, the expression $\oint_C \mathbf{E} \cdot d\mathbf{l} = 0$ is a mathematical statement of Kirchhoff's voltage law.

Question:

Why is it usually easier to compute V for a given charge distribution and then find E using $E = -\nabla V$ than to compute E directly by applying Coulomb's law?

Answer:

Step 1

Coulomb's law involves vector sums and integrals while the expression in differential form involves only scalars. So using $\mathbf{E} = -\nabla V$ is usually easier to compute V for a given charge distribution and then find electric field \mathbf{E} than by applying Coulomb's law.

Question:

What is an electric dipole?

Answer:

Step 1

An electric dipole is made of two point charges of equal magnitude and opposite polarity separated by some distance.

Question:

What are the electromagnetic constitutive parameters of a material medium?

Answer:

Step 1

Materials are classified as conductors or dielectrics.

Step 2

The electromagnetic constitutive properties of a material medium are as follows:

- electrical permittivity ϵ
- magnetic permeability μ and
- conductivity σ

Thus, the electromagnetic constitutive parameters of a material medium are explained.

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