

Class 12 Physics | Chapter 1.12

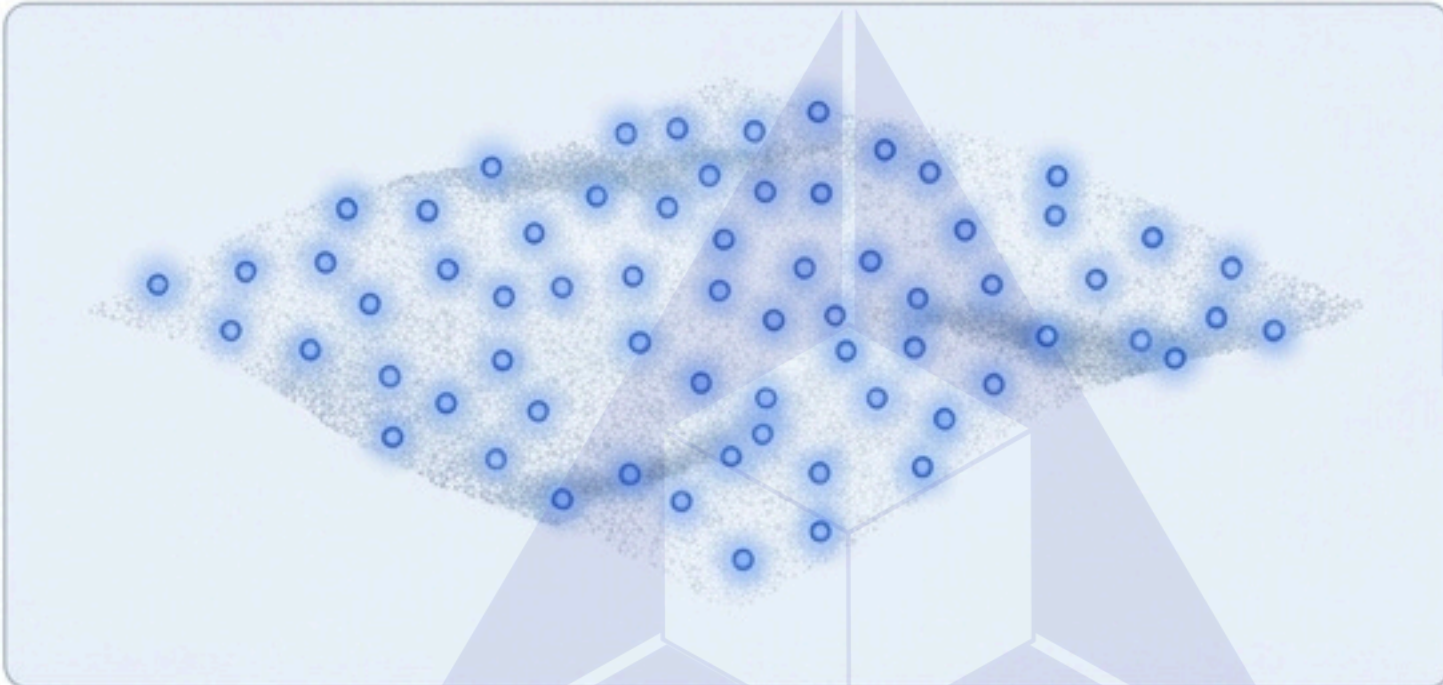
Continuous Charge Distribution

When charges are spread out, not isolated

Transitioning from discrete point charges to macroscopic charge densities to prepare for Gauss's Law.

The Zoom-Out Effect

Microscopic View (Discrete)



Charge is quantised ($q = ne$). For a few charges, we calculate interactions using vector addition and the superposition principle.

Impractical for macroscopic objects containing $10^{13}+$ electrons.

Macroscopic View (Continuous)

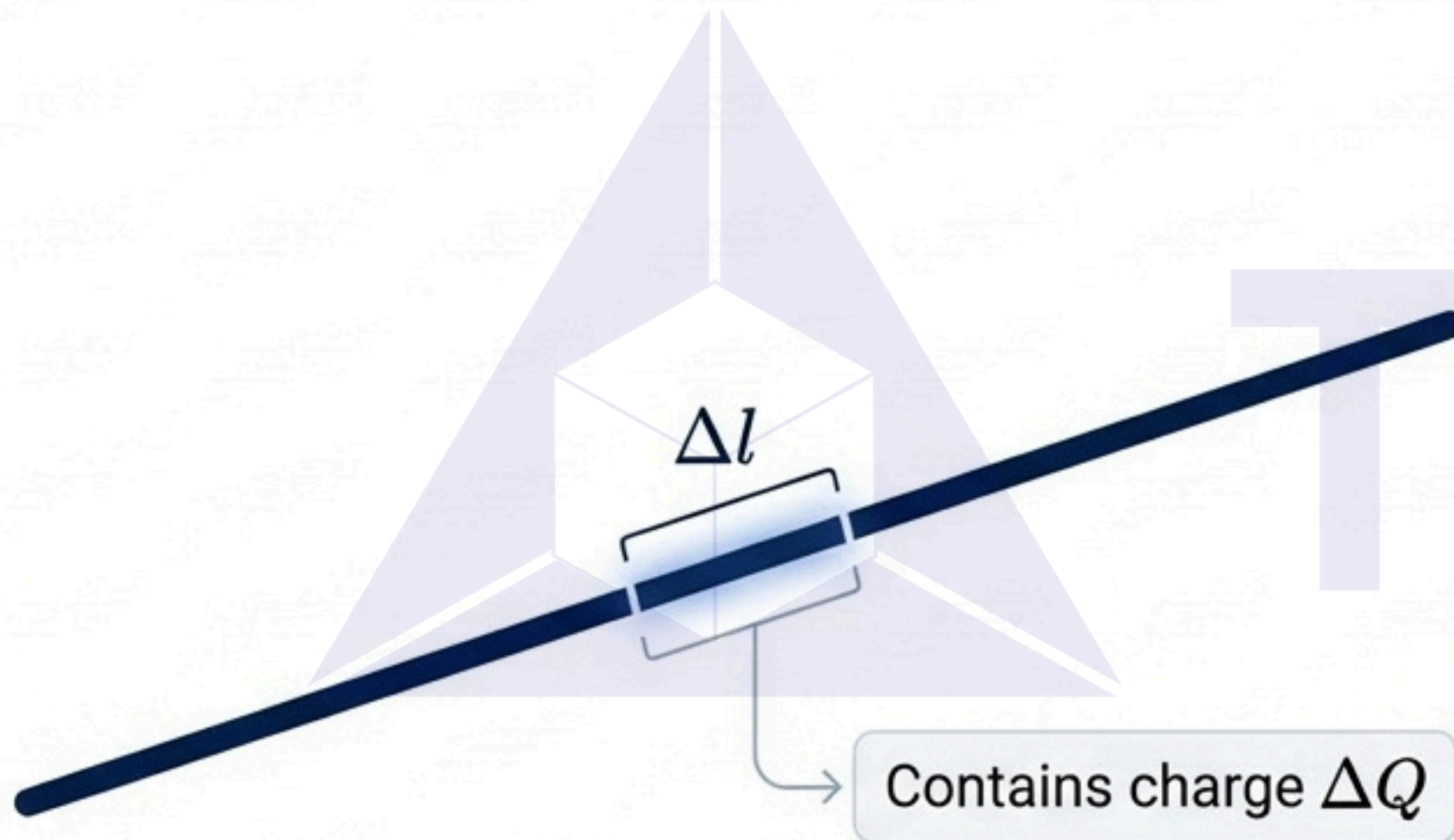


The “grainy” nature of electrons is lost at scale. Charge is treated as a continuous fluid spreading over a line, area, or volume.

Why do we need this? To replace complex, impossible algebraic summations (Σ) with smooth calculus integration ($\int$).

Linear Charge Density

Charge spread along a 1-Dimensional curve or line.



Symbol

λ (Lambda)

Unit

C/m (Coulombs per meter)

Use Cases: Thin straight wires, charged circular rings.

$$\lambda = \frac{\Delta Q}{\Delta l}$$

$$dq = \lambda \cdot dl$$



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$$E=mc^2$$



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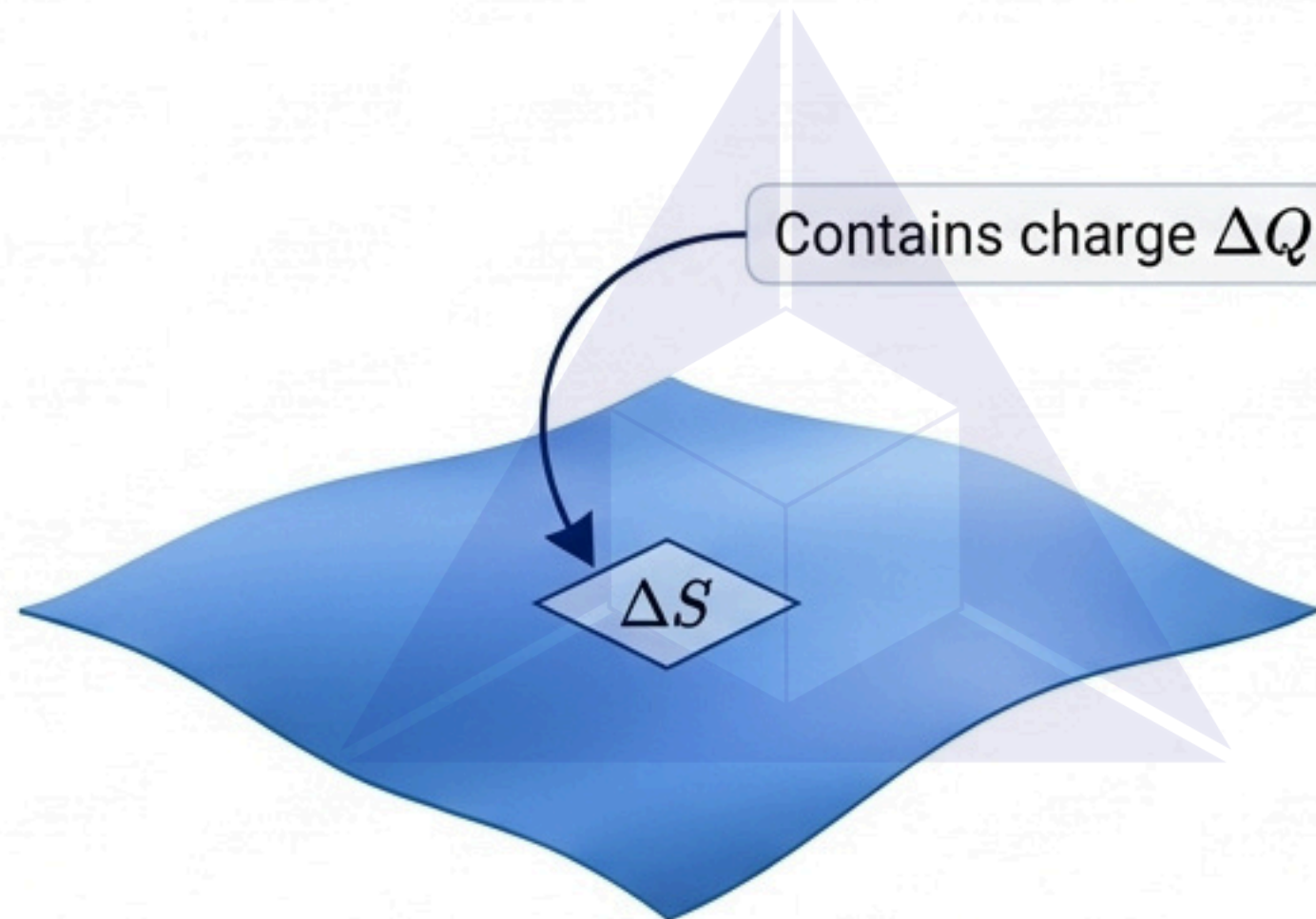
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Surface Charge Density

Charge spread across a 2-Dimensional area.



Symbol

σ (Sigma)

Unit

C/m² (Coulombs per square meter)

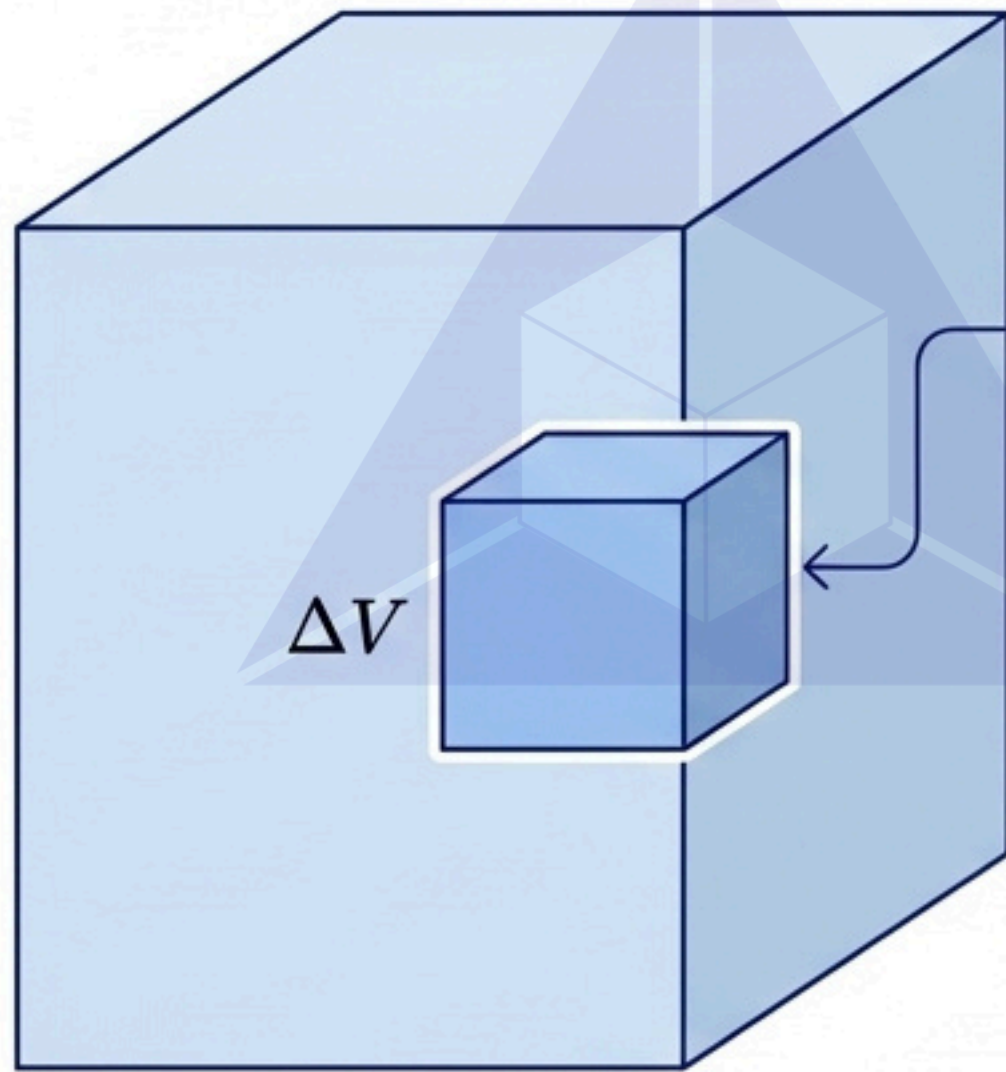
Use Cases: Infinite plane sheets, surfaces of conducting metal spheres.

$$\sigma = \frac{\Delta Q}{\Delta S}$$

$$dq = \sigma \cdot dS$$

Volume Charge Density

Charge distributed throughout a 3-Dimensional space.



Contains charge ΔQ

Symbol

ρ (Rho)

Unit

C/m³ (Coulombs per cubic meter)

Use Cases: Non-conducting solid spheres, thick dielectric slabs.

$$\rho = \frac{\Delta Q}{\Delta V}$$

$$dq = \rho \cdot dV$$

Key Takeaway: The Bridge to Gauss's Law

Continuous charge distributions allow us to mathematically define “charge enclosed” inside any Gaussian surface using integration:

$$Q_{\text{encl}} = \int \lambda dl$$

$$Q_{\text{encl}} = \int \sigma dS$$

$$Q_{\text{encl}} = \int \rho dV$$

Identify the correct density for each scenario:

Charge on the outer skin of a metal sphere.

σ

Charge uniformly packed inside a plastic sphere.

ρ

Charge distributed over a thin nylon thread.

λ

→ NEXT: Gauss's Law (Section 1.13)



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