



Electrostatics: *Charge Distributions*

EE3321

Electromagnetic Field Theory



Outline



- Charge Distributions
- Fields Around Charge Distributions
- Recipe to Calculate Field Around Charge Distributions

Charge Distributions



Point Charge

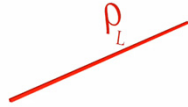


Size: infinitely small

Q

Total Charge: Q

Line Charge



Size: Length L

Charge Density: Coulombs/Meter
(C/m)

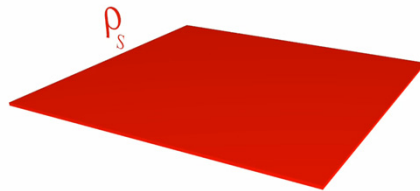
Total Charge:

$$Q = \begin{cases} \int_L \rho_\ell d\ell & \text{general case} \\ \rho_\ell L & \text{uniform } \rho_\ell \end{cases}$$

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Surface Charge



Size: Length L
Width W

Charge Density: Coulombs/Meter²
(C/m²)


Total Charge:

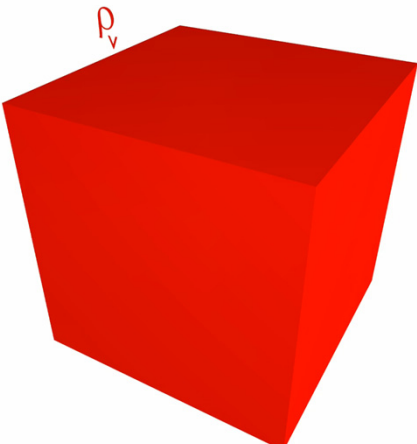
$$Q = \begin{cases} \iint_S \rho_s ds & \text{general case} \\ \rho_s S & \text{uniform } \rho_s \end{cases}$$

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Volume Charge





Size: Length L
 Width W
 Height H


Charge Density: Coulombs/Meter³
 (C/m³)


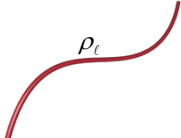

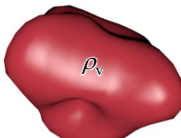
Total Charge:

$$Q = \begin{cases} \iiint_v \rho_v dv & \text{general case} \\ \rho_v v & \text{uniform } \rho_v \end{cases}$$

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Charge Distribution Summary



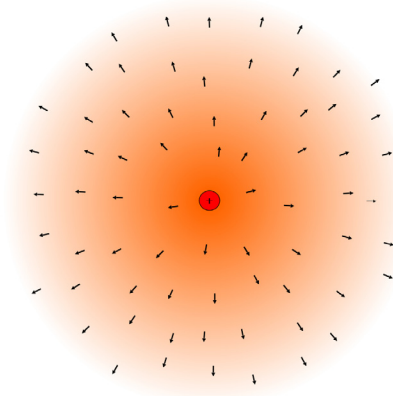
Point Charge	Line Charge	Sheet Charge	Volume Charge
Q 	ρ_ℓ 	ρ_s 	ρ_v 
Charge Q (C)	Line Charge Density ρ_ℓ (C/m)	Surface Charge Density ρ_s (C/m ²)	Volume Charge Density ρ_v (C/m ³)
Total Charge $Q_{\text{Total}} = \sum_{i=1}^N Q_i$	Total Charge $Q_{\text{Total}} = \int \rho_\ell dl \cong \rho_\ell L$	Total Charge $Q_{\text{Total}} = \iint_S \rho_s ds \cong \rho_s S$	Total Charge $Q_{\text{Total}} = \iiint_v \rho_v dv = \rho_v V$
Total Field $\vec{D}_{\text{Total}} = \sum_{i=1}^N \frac{Q_i}{4\pi R_i^2} \hat{a}_{R_i}$	Total Field $\vec{D}_{\text{Total}} = \int \frac{\rho_\ell dl}{4\pi R^2} \hat{a}_R$	Total Field $\vec{D}_{\text{Total}} = \iint_S \frac{\rho_s ds}{4\pi R^2} \hat{a}_R$	Total Field $\vec{D}_{\text{Total}} = \iiint_v \frac{\rho_v dv}{4\pi R^2} \hat{a}_R$

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Fields Around Charge Distributions

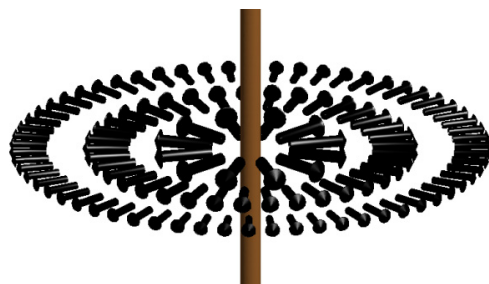


Point Charge



$$\vec{D} = \frac{Q}{4\pi r^2} \hat{a}_r$$

Infinite Line Charge

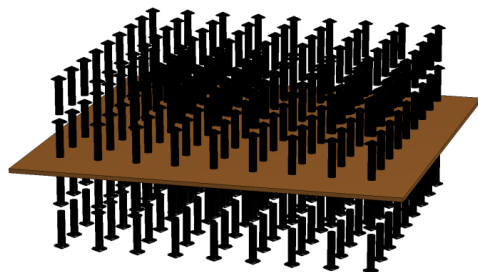


$$\vec{D} = \frac{\rho_L}{2\pi\rho} \hat{a}_\rho$$

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Infinite Surface Charge



$$\vec{D}_{\text{total}} = \frac{\rho_S}{2} \hat{a}_z$$

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Recipe to Calculate Field Around Charge Distributions



Recipe for Solving Problems



1. Draw the problem and label with all dimensions and parameters.
2. Choose a coordinate system to make math easier.
3. Write general equation.

	Point	Line	Surface	Volume
Q_{Total}	$\sum_i Q_i$	$\int \rho \, dl$	$\iint \rho \, ds$	$\iiint \rho \, dv$
D_{Total}	$\sum_i \frac{Q_i}{4\pi R_i^2} \hat{a}_i$	$\int \frac{\rho \, dl}{4\pi R^2} \hat{a}_k$	$\iint \frac{\rho \, ds}{4\pi R^2} \hat{a}_k$	$\iiint \frac{\rho \, dv}{4\pi R^2} \hat{a}_k$

4. Write expressions for each term in the integral.
5. Choose limits of integration.
6. Solve the integral.
7. Interpret the result.