

8.4 Electric Fields of Charge Distributions

Name: _____ Class: _____ Date: _____ Total: 8 marks

KEY WORDS linear charge density 线电荷密度 • volume charge density 体电荷密度

- surface charge density 面电荷密度 • symmetry 对称性
- continuous charge distribution 连续电荷分布

Objective

Build the skills to answer exam questions on **electric fields of charge distributions**.**You must be able to:**

- treat a **continuous charge distribution** 连续电荷分布 as many elements dq
- relate dq to **linear**, **surface**, and **volume charge density** (λ , σ , ρ)
- set up an **integral** for the field of a symmetric distribution
- use **symmetry** 对称性 to see which field components cancel

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ From point charge to integral

Split the charge into elements dq , each giving $dE = \frac{1}{4\pi\epsilon_0} \frac{dq}{r^2}$, then $\vec{E} = \int d\vec{E}$.

■ Charge densities

 $\lambda = \frac{dq}{dl}$ (per length), $\sigma = \frac{dq}{dA}$ (per area), $\rho = \frac{dq}{dV}$ (per volume).

■ Symmetry and the far field

By symmetry, components perpendicular to the axis cancel; only the axial part survives. Far away, any finite distribution looks like a **point charge** ($E \rightarrow kQ/r^2$).

2 Practice

2.1 Write the charge dq on a length dl of a rod with linear charge density λ . [1]**2.2** State the SI units of surface charge density σ . [1]**2.3** State what the field of any finite charge distribution looks like from very far away. [1]

3 Exam-style questions

3.1 The linear charge density λ is defined as [1]

- | | |
|---|---|
| A | B |
| C | D |
- A** charge per unit volume
 - B** charge per unit area
 - C** charge per unit length
 - D** charge $\times$ length

3.2 To find the field of a continuous distribution you [1]

- | | |
|---|---|
| A | B |
| C | D |
- A** add two point charges
 - B** integrate $d\vec{E}$ over all the charge elements dq
 - C** use $V = IR$
 - D** ignore symmetry

3.3 A ring of radius a carries total charge Q . On its axis at distance x the field is $E = \frac{kQx}{(x^2 + a^2)^{3/2}}$.(a) State the field at the centre of the ring ($x = 0$). [1](b) State what E approaches when $x \gg a$, and explain. [2]