

18.4 Electric field of a point charge

Name: _____ Class: _____ Date: _____

Total: 22 marks

KEY WORDS electric field 电场 • electric field strength 电场强度 • gravitational field 重力场
• force 力 • point charge 点电荷

Objective

Build the skills to answer exam questions on the **electric field of a point charge**.

You must be able to:

- use $E = \frac{Q}{4\pi\epsilon_0 r^2}$
- compare electric and gravitational fields

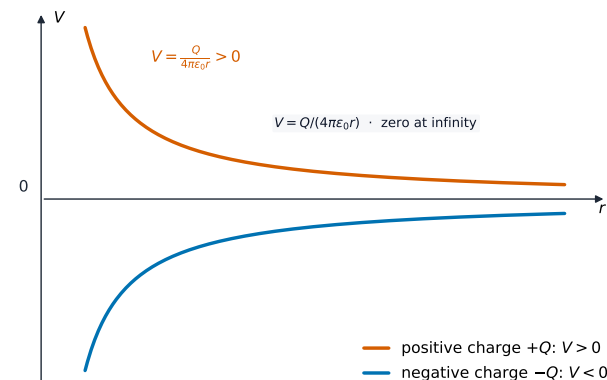
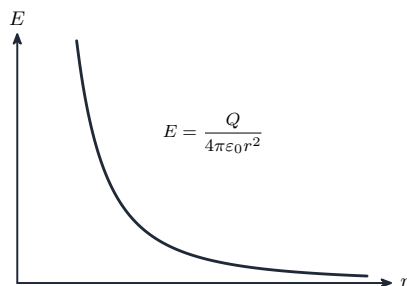
1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Field of a point charge

$$E = \frac{Q}{4\pi\epsilon_0 r^2}.$$

It points **out** from a positive charge and **in** to a negative one, and falls as an **inverse square**:



The radial field of a point charge

This is just like the **gravitational** field $g = GM/r^2$ — except gravity is **always attractive**, while the electric field can be attractive or repulsive.

2 Practice

Now apply the methods above.

2.1 Write the equation for the field strength E due to a **point charge**. [1]

2.2 State how E varies with distance r from a point charge. [1]

2.3 Find the field strength at 0.10 m from a +5.0 nC point charge. ($\frac{1}{4\pi\epsilon_0} = 9.0 \times 10^9$.) [2]

3 Exam-style questions

3.1 Both the electric field of a point charge and the gravitational field of a point mass vary with distance as: [1]

- | | |
|---|---------|
| A | $1/r$ |
| B | $1/r^2$ |
| C | r |
| D | r^2 |

3.2 Calculate the electric field strength at 2.0 cm from a point charge of +8.0 nC. [3]

3.3 State **one** similarity and **one** difference between an electric field and a gravitational field. [2]

3.4 An isolated solid metal sphere of radius R carries a positive charge $+Q$. Point Q lies outside the sphere, a distance $2R$ from its centre.

(a) **Explain** why the electric potential everywhere near an isolated **positive** charge is positive. [2]

(b) **State** the direction of the electric field at point Q, and **state** how the field inside the metal sphere compares with it. [2]

(c) On the axes below, **sketch** the variation of the electric field strength E with distance x from the centre of the sphere, for x from 0 to $4R$. [3]

(d) The field strength at the surface of the sphere is E_0 . **Determine**, in terms of E_0 , the field strength at point Q. [2]

(e) A second identical sphere carrying the same charge is now placed with its centre $6R$ from the centre of the first. **Determine** the position on the line joining their centres at which the resultant field is zero, and **state** what the potential is there compared with the potential at the surface of either sphere. [3]