

Exercise walk-through

8.3

Electric Fields

AP Physics C: Electricity and Magnetism

Electric fields and field lines

The **electric field** is force per unit positive **test charge** :

Field of a point charge

$$\vec{E} = \frac{\vec{F}}{q_0}, \quad \vec{E} = k \frac{q}{r^2} \hat{r}$$

- lines leave +, enter -; denser = stronger
- lines never cross; $\vec{F} = q\vec{E}$ on any charge



dipole field

Worked example – Coulomb's law with numbers

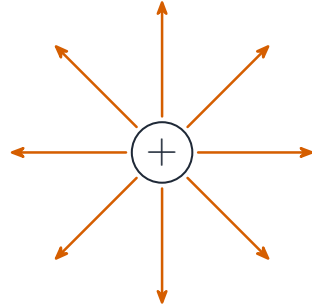
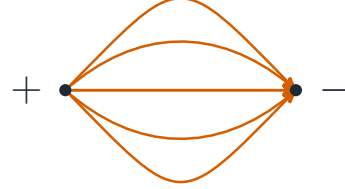
Two $+2.0 \mu\text{C}$ point charges sit 0.30 m apart. Find the force on each.

- $F = \frac{kq_1q_2}{r^2}$
- $= \frac{(9.0 \times 10^9)(2.0 \times 10^{-6})^2}{(0.30)^2}$
- $= 0.40 \text{ N, repulsive}$

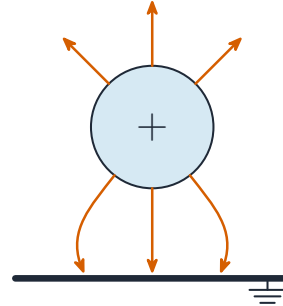
Both charges feel 0.40 N : Newton's third law, whatever the sizes of q_1 and q_2 . Get the **direction** from the signs, never from the algebra.

Electric field-line patterns for parallel plates

a) parallel plates (uniform field) b) dipole (+ and -)



c) point charge (radial)



d) sphere above earthed plate

Electric field-line patterns for parallel plates, a dipole, and a point charge

Exercises 2.1-2.3

2.1 Find the electric field 0.20 m from a $+5.0 \mu\text{C}$ charge ($k = 8.99 \times 10^9$). [2]

2.2 A $+2.0 \mu\text{C}$ charge sits in a field of 3000 N C^{-1} . Find the force on it. [2]

2.3 State the direction of the field around a negative point charge. [1]

Exercises 2.1-2.3

2.1 Find the electric field 0.20 m from a $+5.0 \mu\text{C}$ charge ($k = 8.99 \times 10^9$). [2]

2.1

- $$E = k \frac{q}{r^2} = 8.99 \times 10^9 \times \frac{5.0 \times 10^{-6}}{(0.20)^2} = 1.1 \times 10^6 \text{ N C}^{-1}$$

2.2 A $+2.0 \mu\text{C}$ charge sits in a field of 3000 N C^{-1} . Find the force on it. [2]

2.2

- $$F = qE = (2.0 \times 10^{-6})(3000) = 6.0 \times 10^{-3} \text{ N}$$

2.3 State the direction of the field around a negative point charge. [1]

2.3

- radially inward, toward the charge

Exercises 3.1-3.2

3.1 The electric field is defined as

[1]

☐

A qF

B F/q

C q/F

D qr^2

3.2 The force on a charge q in a field E is

[1]

☐

A q/E

B qE

C E/q

D qE^2

Exercises 3.1-3.2

3.1 The electric field is defined as

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- F/q .

3.2 The force on a charge q in a field E is

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3.2 B

- qE .

Exercise 3.3 (a)

3.3 A $+4.0 \mu\text{C}$ charge is at the origin.

(a) Find the electric field 0.30 m from it.

[2]

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(a) Find the electric field 0.30 m from it.

[2]

(a)

- $$E = 8.99 \times 10^9 \times \frac{4.0 \times 10^{-6}}{(0.30)^2} = 4.0 \times 10^5 \text{ N C}^{-1}$$

Exercise 3.3 (b)

3.3 A $+4.0 \mu\text{C}$ charge is at the origin.

(b) Find the force on a $-1.0 \mu\text{C}$ charge placed there, with direction.

[2]

Exercise 3.3 (b)

3.3 A $+4.0 \mu\text{C}$ charge is at the origin.

(b) Find the force on a $-1.0 \mu\text{C}$ charge placed there, with direction. [2]

(b)

- $F = qE = (1.0 \times 10^{-6})(4.0 \times 10^5) = 0.40 \text{ N}$, directed toward the $+4.0 \mu\text{C}$ charge (attractive)