Phys102 Lecture 2

The Electric Field

Key Points

- Coulomb's Law
- The electric field (**E** is a vector!)

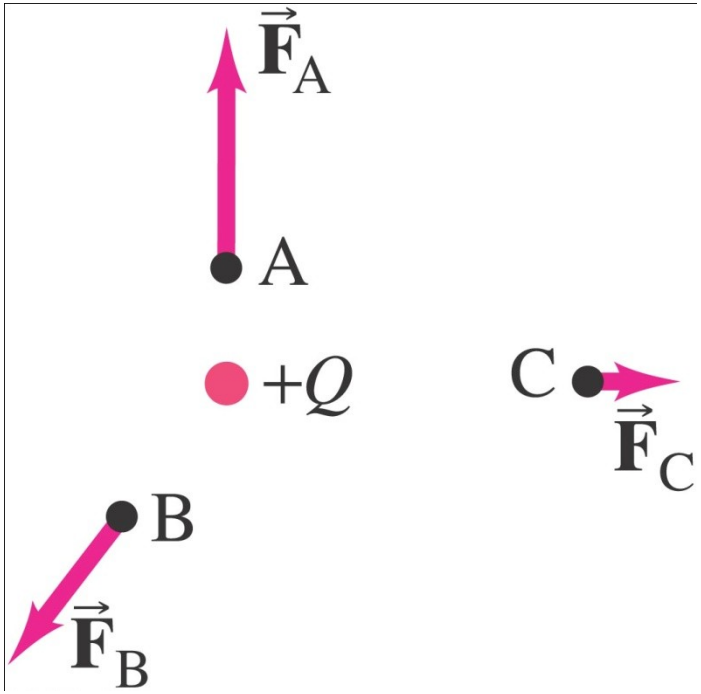
References

Textbook: 16-1,2,3,4,5,6,7,8,9,+.

The Electric Field

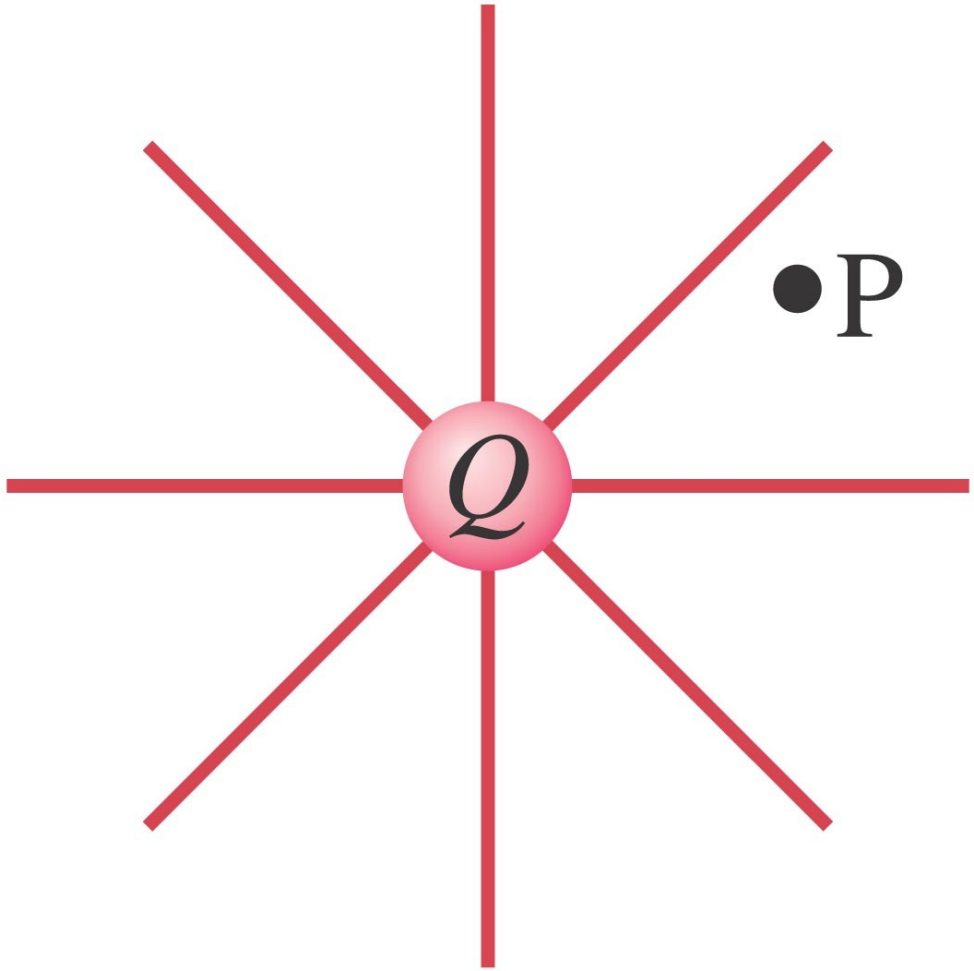
The electric field is defined as the force on a small charge, divided by the magnitude of the charge:

$$\vec{\mathbf{E}} = \frac{\vec{\mathbf{F}}}{q}.$$



The Electric Field

An electric field surrounds every charge.



The Electric Field

For a point charge:

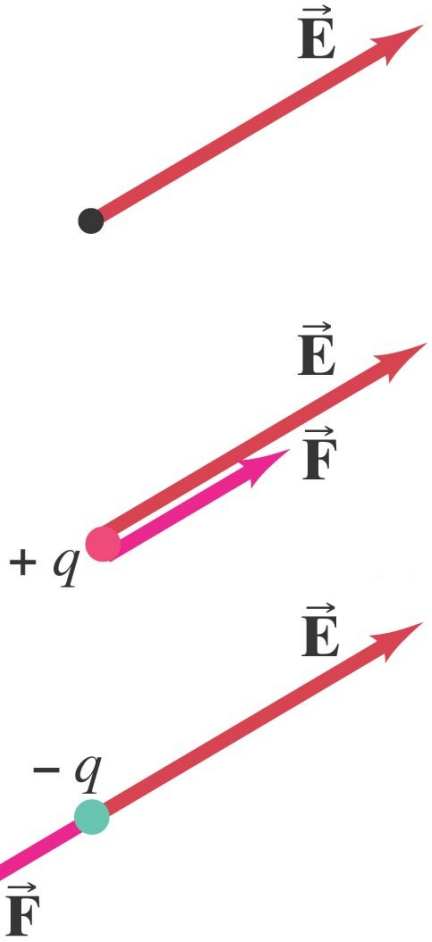
The magnitude of the electric field due to charge Q:

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$$

The Electric Field

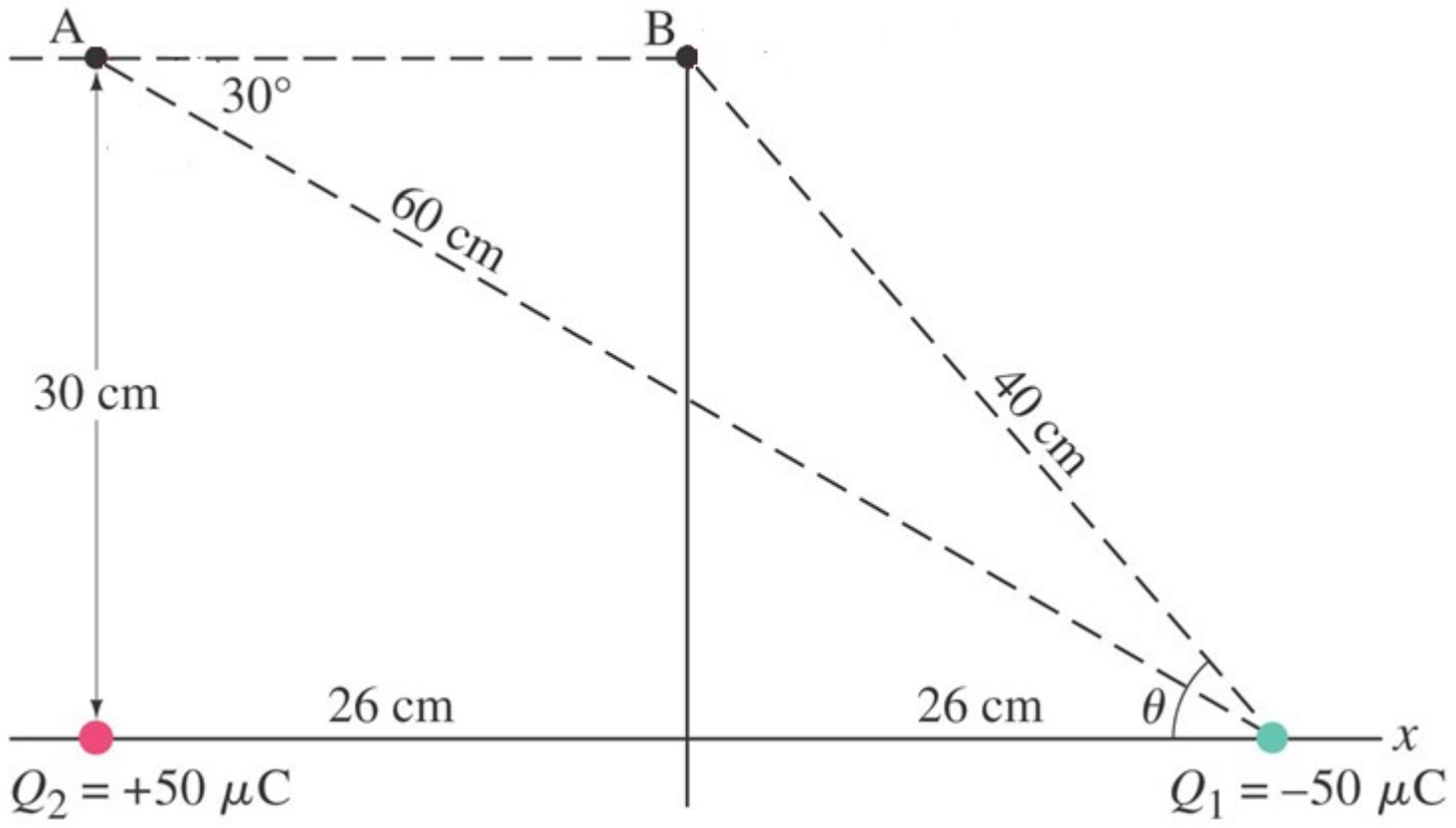
Force on a point charge in an electric field:

$$\vec{\mathbf{F}} = q\vec{\mathbf{E}}.$$



Example: Electric field above two point charges.

Calculate the total electric field (a) at point A and (b) at point B in the figure due to both charges, Q_1 and Q_2.



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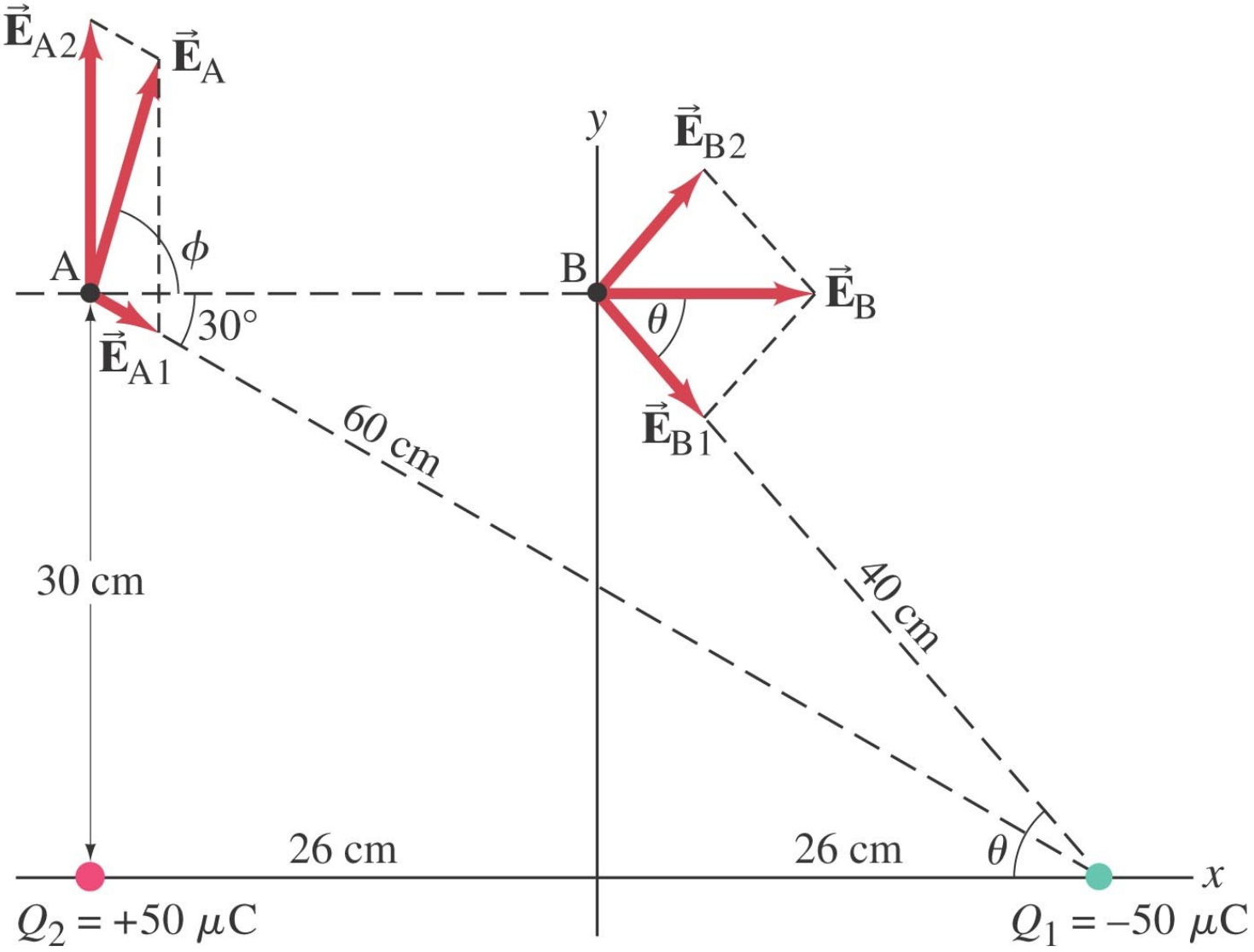


Problem solving in electrostatics: electric forces and electric fields

1. Draw a diagram; show all charges, with signs, and electric fields and forces with directions.

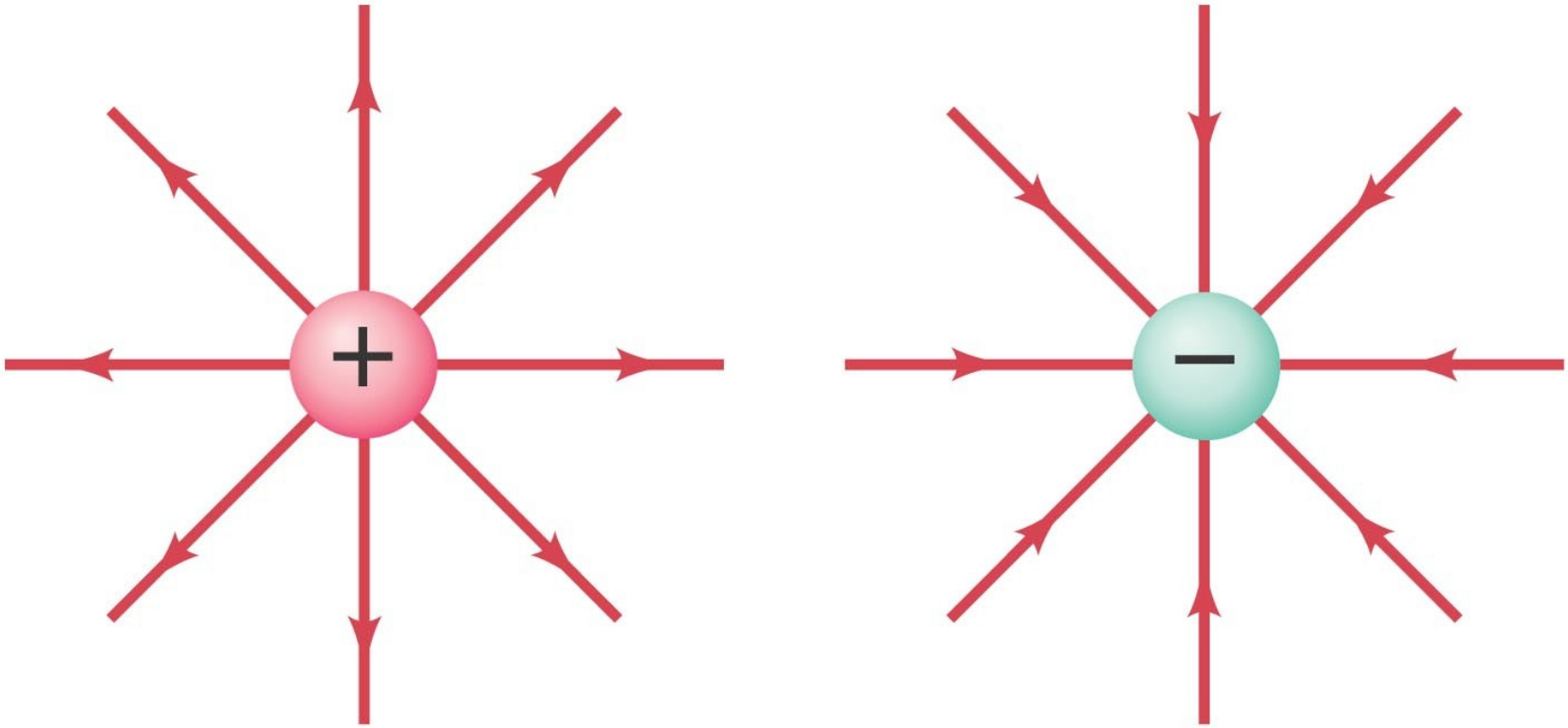
2. Calculate forces using Coulomb's law.

3. Add forces vectorially to get result.

4. Check your answer!

Field Lines

The electric field can be represented by field lines. These lines start on a positive charge and end on a negative charge.



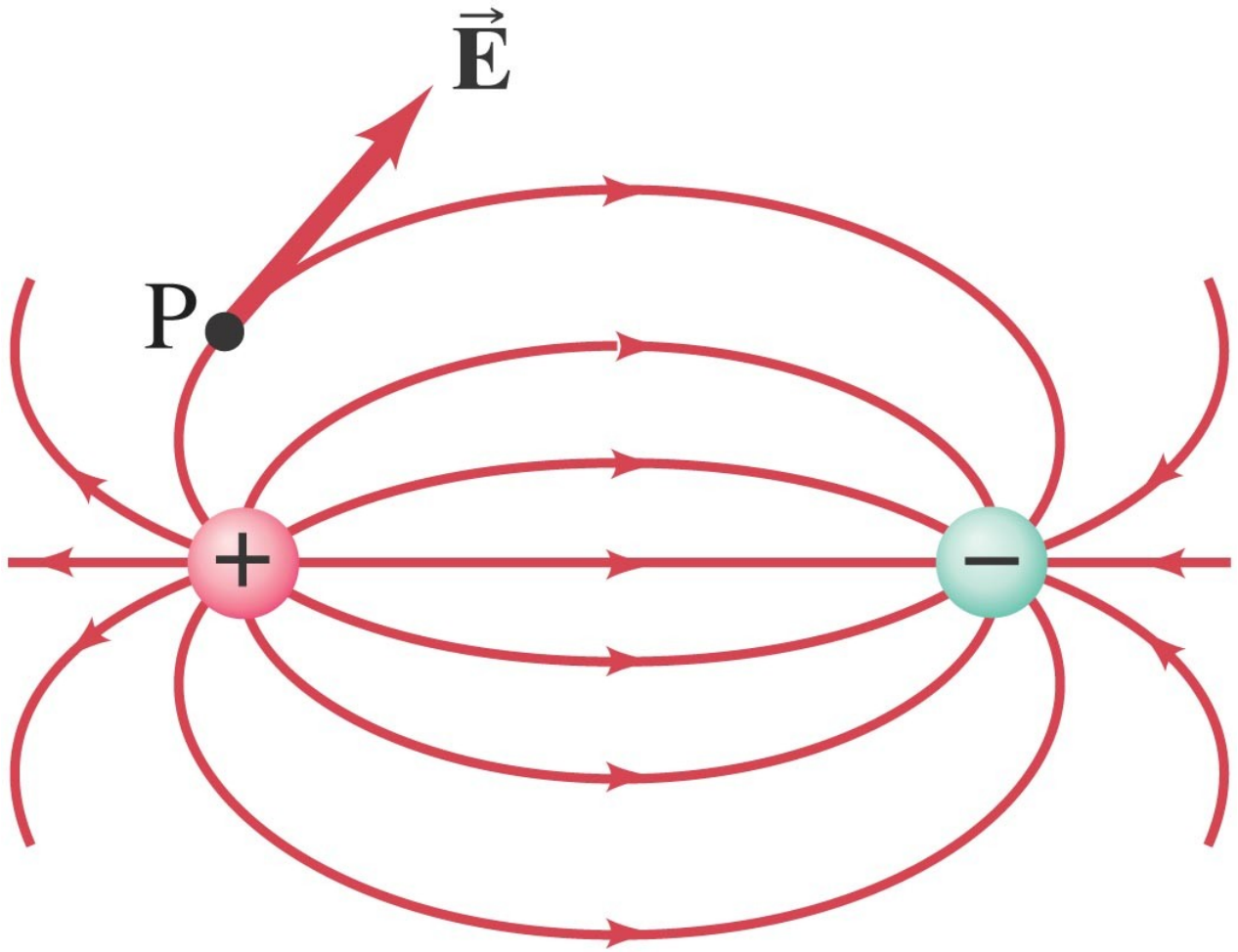
Field Lines

The number of field lines starting (ending) on a positive (negative) charge is proportional to the magnitude of the charge.

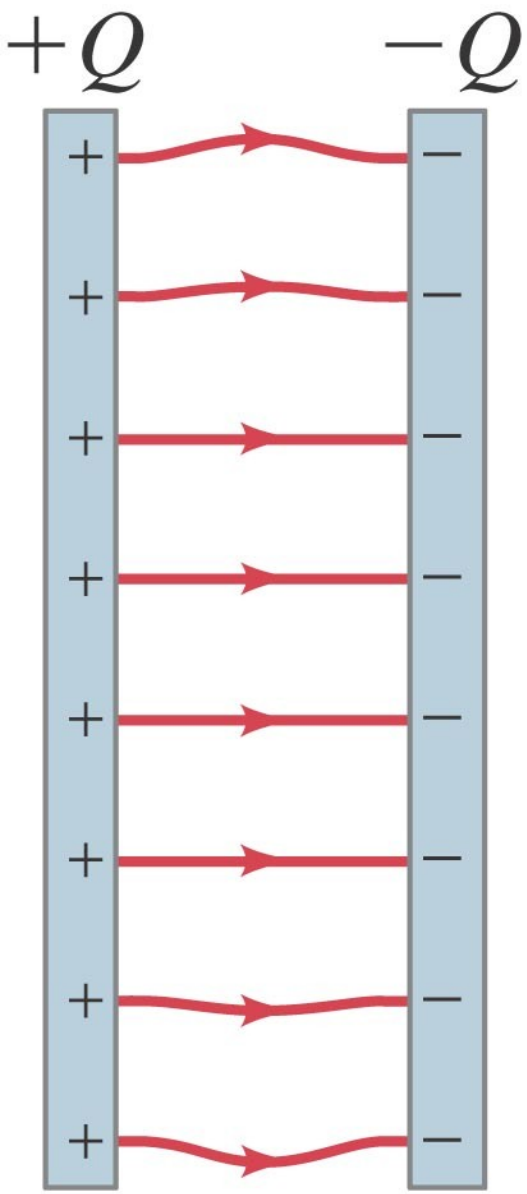
The electric field is stronger where the field lines are closer together.

Field Lines

Electric dipole: two equal charges, opposite in sign:



Field Lines



The electric field between two closely spaced, oppositely charged parallel plates is constant.

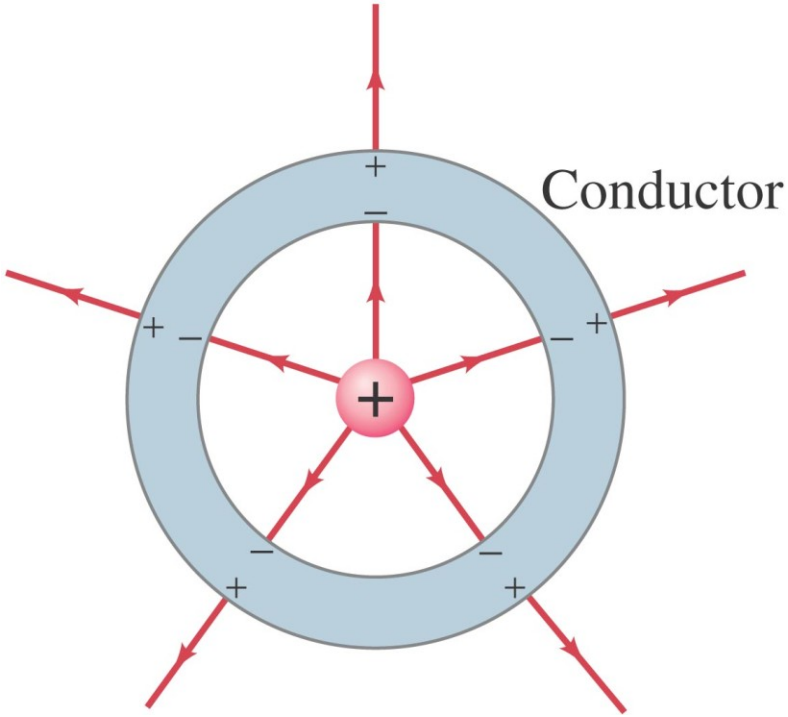
Field Lines

Summary of field lines:

1. **Field lines indicate the direction of the field; the field is tangent to the line.**
2. **The magnitude of the field is proportional to the density of the lines.**
3. **Field lines start on positive charges and end on negative charges; the number is proportional to the magnitude of the charge.**

Electric Fields and Conductors

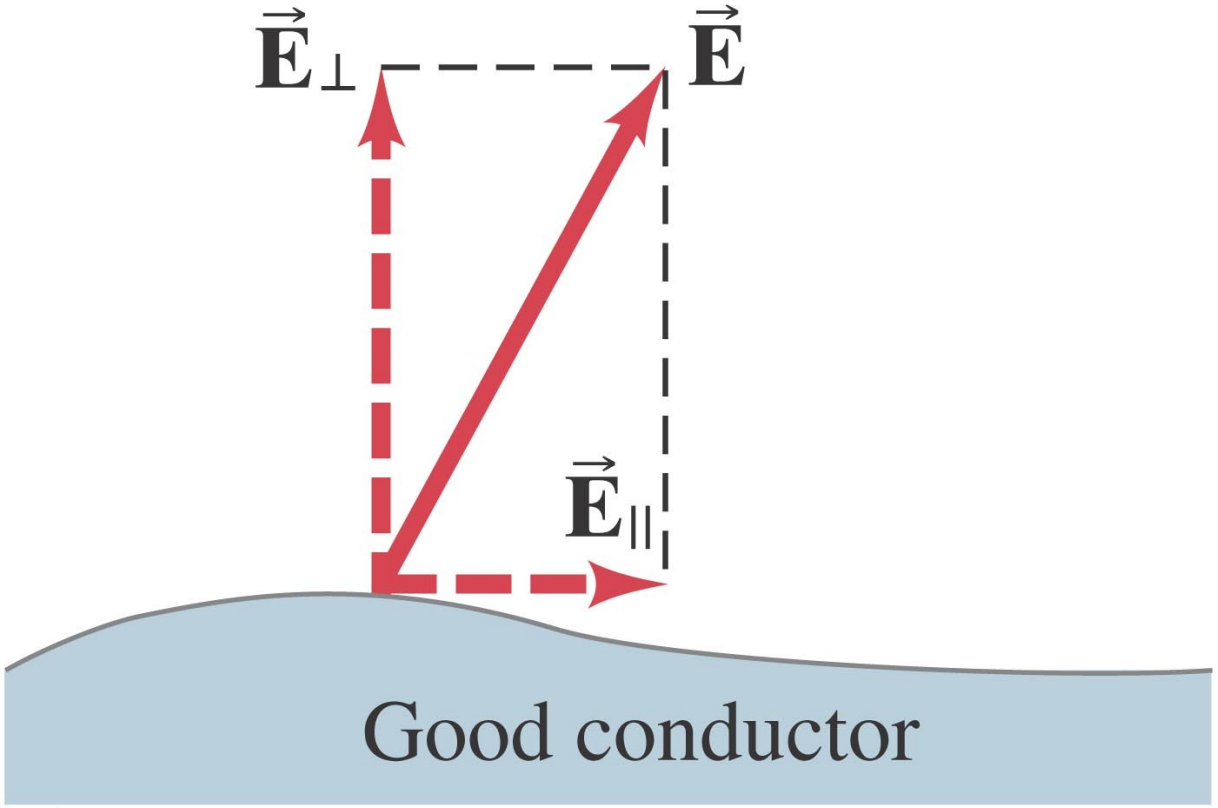
The static electric field inside a conductor is zero – if it were not, the charges would move.



The net charge on a conductor resides on its outer surface.

Electric Fields and Conductors

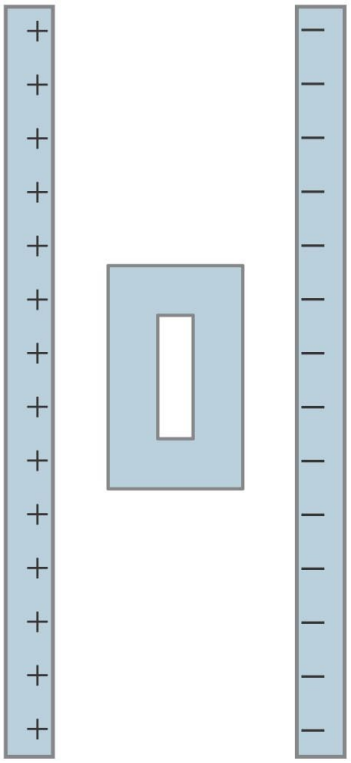
The electric field is perpendicular to the surface of a conductor – again, if it were not, charges would move.



Electric Fields and Conductors

Conceptual Example: Shielding, and safety in a storm.

A neutral hollow metal box is placed between two parallel charged plates as shown. What is the field like inside the box?



i-clicker quiz 2-1

A metal ball hangs from the ceiling by an insulating thread. The ball is attracted to a positive-charged rod held near the ball. The charge of the ball must be:

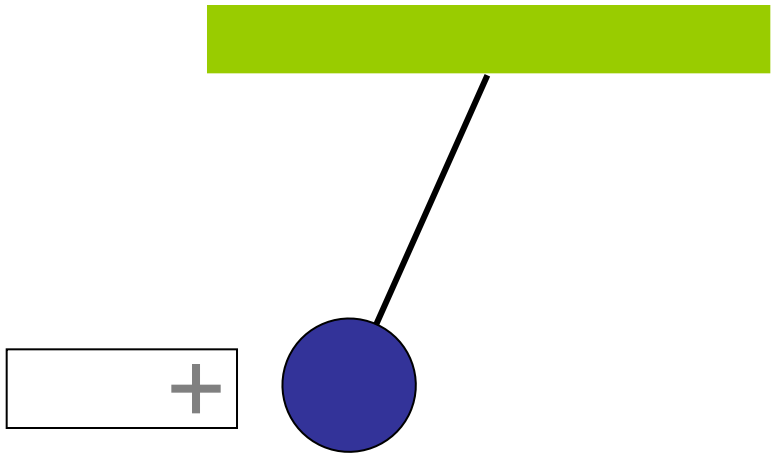
A) positive

B) negative

C) neutral

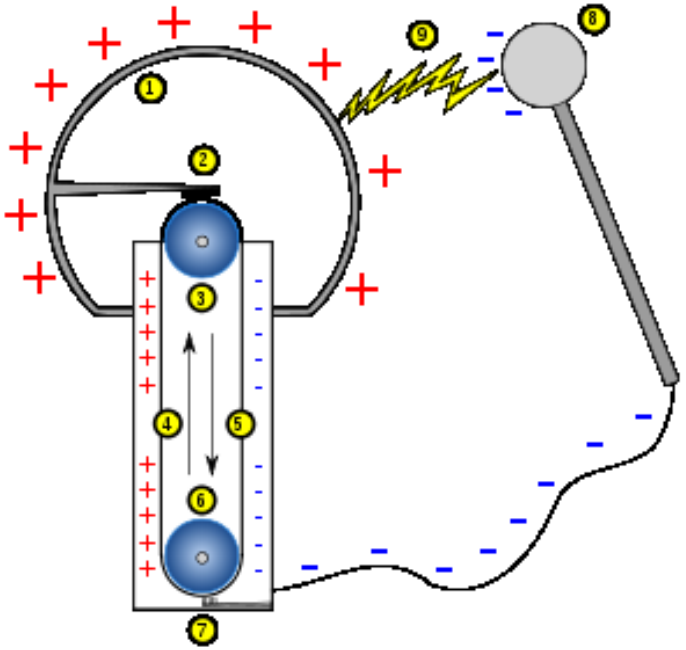
D) positive or neutral

E) negative or neutral



Van de Graaff Generator

The electric field is defined as the force on a small charge, divided by the magnitude of the charge:



i-clicker 2-2

Two neutral conductors are connected by a wire and a charged rod is brought near, but *does not touch*. The wire is taken away, and then the charged rod is removed. What are the charges on the conductors?

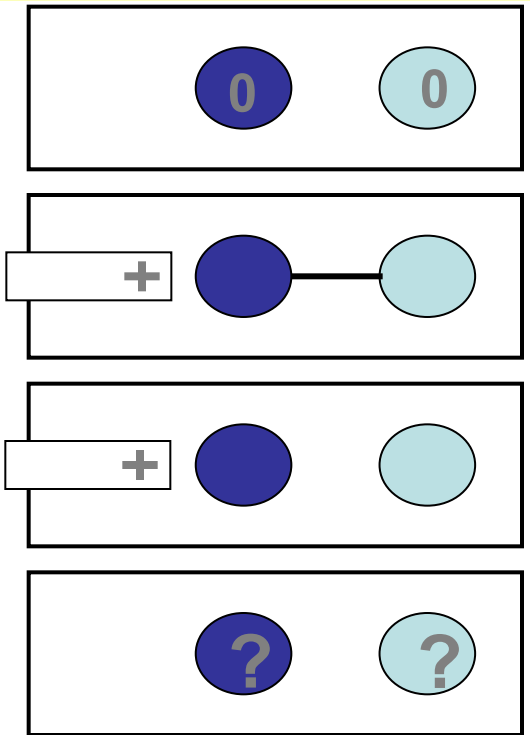
A) 0 0

B) + –

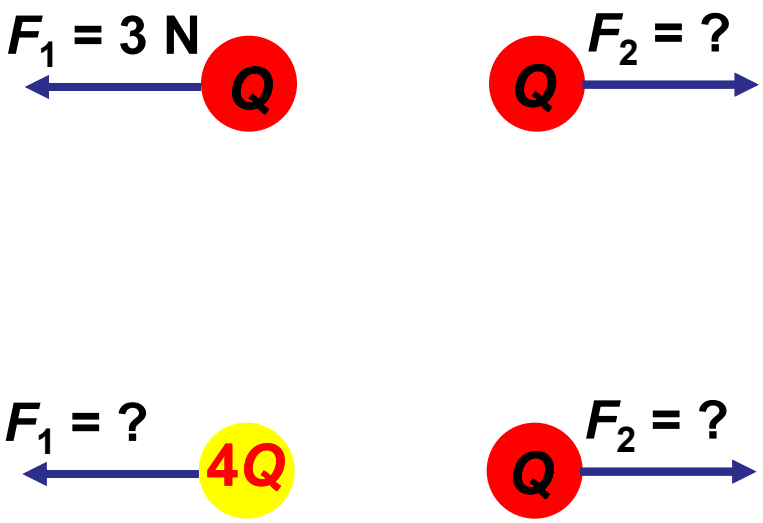
C) – +

D) + +

E) – –



i-clicker 2-3



A) 3/4 N

B) 3.0 N

C) 12 N

D) 16 N

E) 48 N

If we increase one charge to 4*Q*, what is the magnitude of F_1?

i-clicker 2-4

The force between two charges separated by a distance *d* is *F*. If the charges are pulled apart to a distance 3*d*, what is the force on each charge?

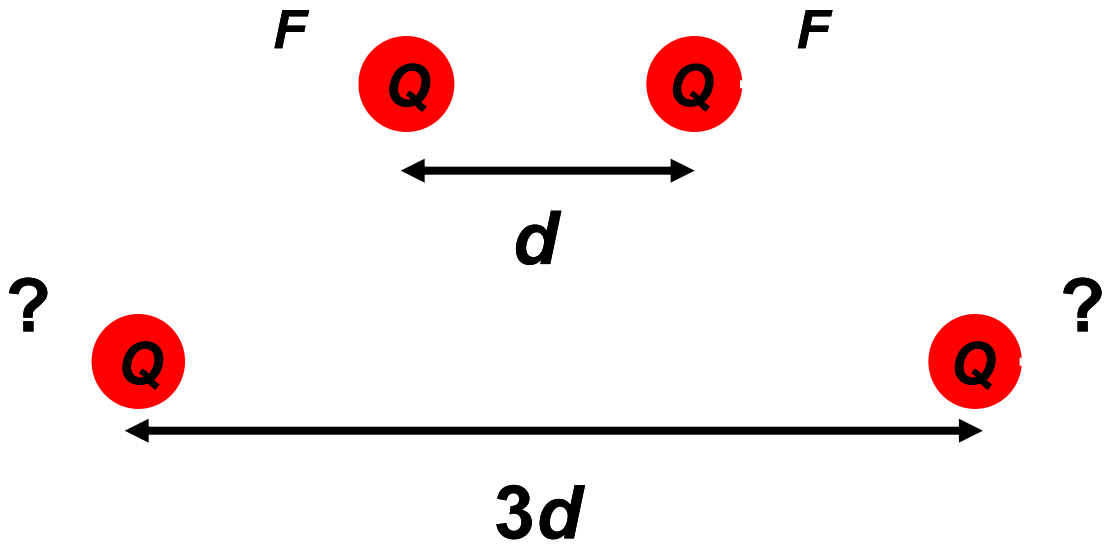
A) 9*F*

B) 3*F*

C) *F*

D) 1/3*F*

E) 1/9*F*



i-clicker 2-5

You are sitting a certain distance from a point charge, and you measure an electric field of E_0. If the charge is doubled and your distance from the charge is also doubled, what is the electric field strength now?

A) $4E_0$

B) $2E_0$

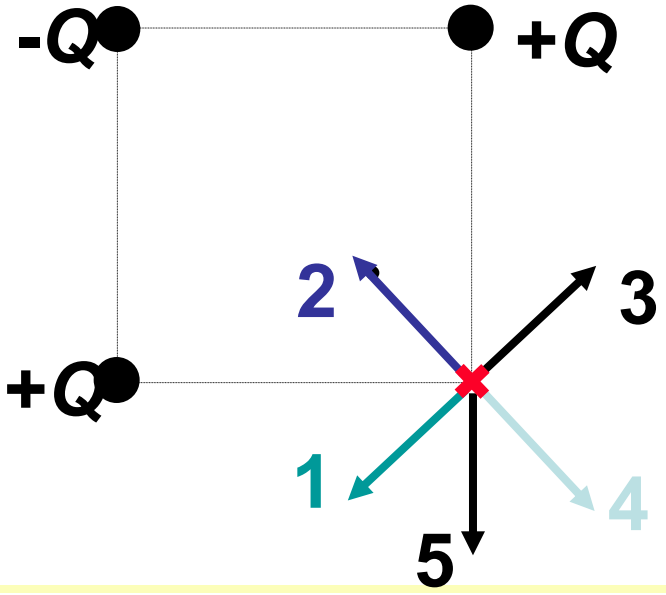
C) E_0

D) $1/2E_0$

E) $1/4E_0$

i-clicker 2-6

What is the direction of the electric field at the position of the *X* ?



A) 1

B) 2

C) 3

D) 4

E) 5