

Electric Field

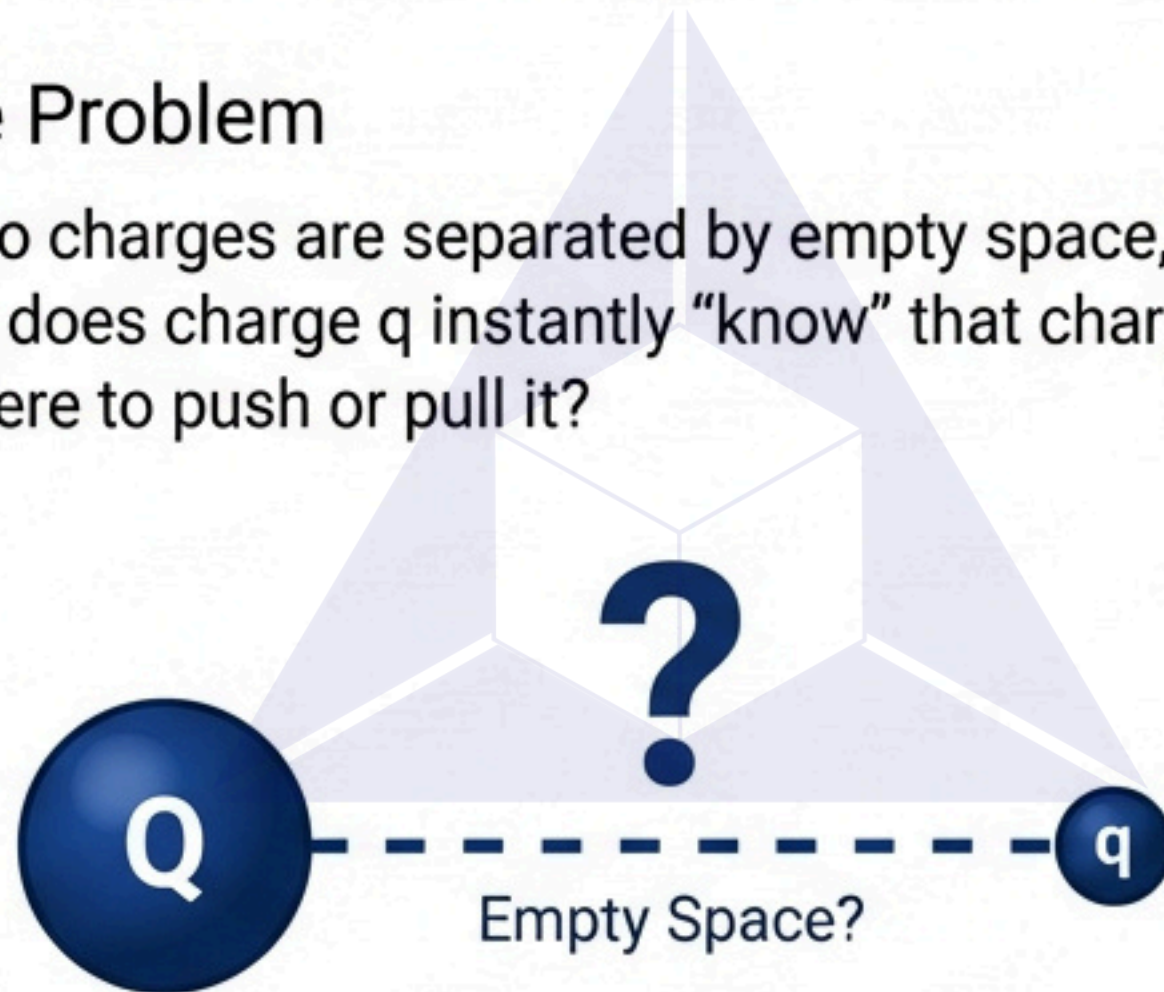
The invisible influence around electric charge

Why We Need the Field Idea

Solving the mystery of “Action at a Distance”

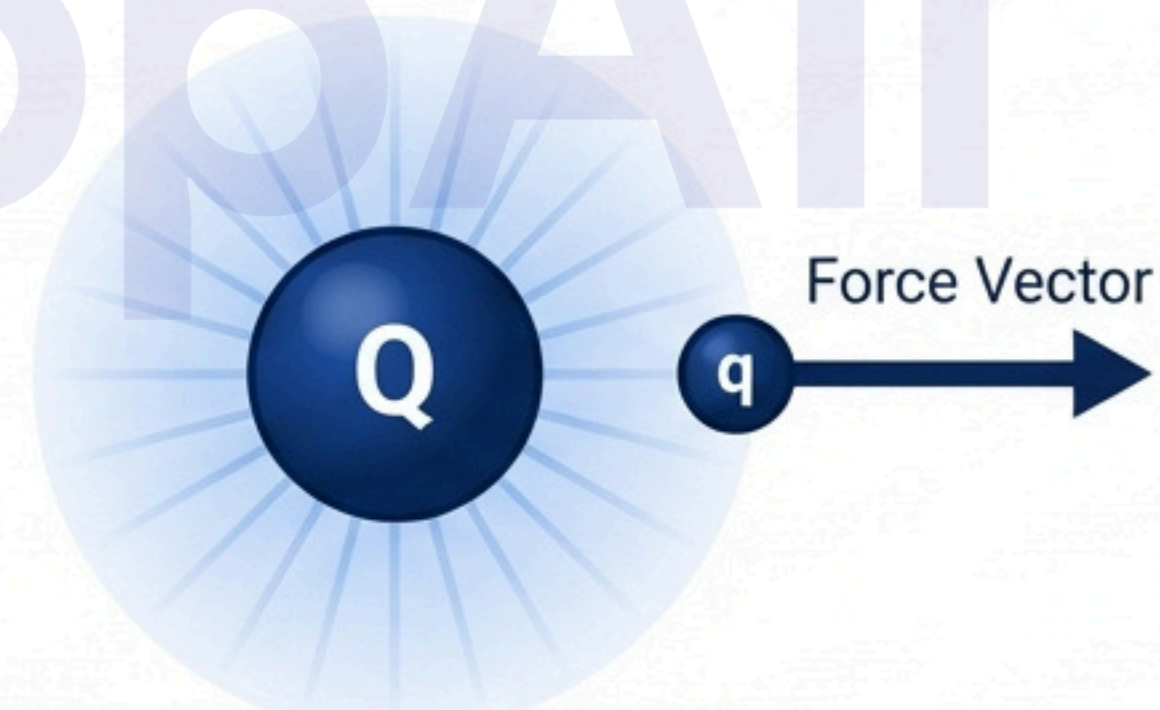
The Problem

If two charges are separated by empty space, how does charge q instantly “know” that charge Q is there to push or pull it?



The Solution

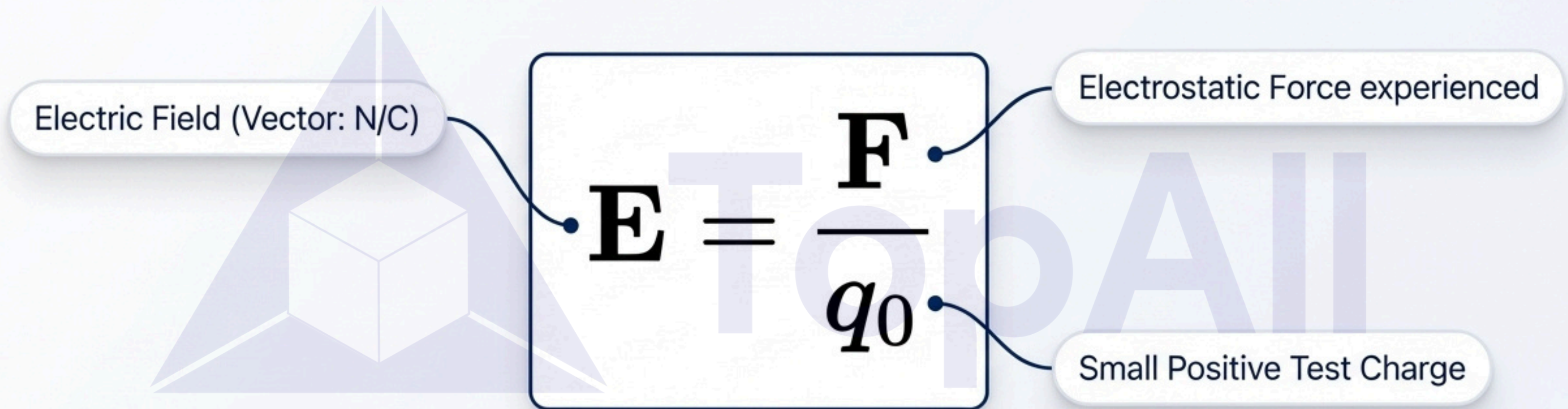
Charge Q modifies the space around it by creating an Electric Field. When q enters this space, the field is what applies the force on q .



⚠ Exam Trap: The field acts as a messenger. Force is not instantaneous; the electromagnetic field propagates at the speed of light (c).

Defining the Electric Field

Force per unit positive test charge



Electric Field (Vector: N/C)

$$\mathbf{E} = \frac{\mathbf{F}}{q_0}$$

Electrostatic Force experienced

Small Positive Test Charge



Crucial Limit: $\lim(q_0 \rightarrow 0)$

The test charge must be vanishingly small. If it's too large, its own field will push the source charge and alter the very setup we are trying to measure!



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$$E=mc^2$$



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Source Charge vs. Test Charge

Understanding the actors in the electrostatic environment



Source Charge (Q)

- The "Creator"
- Produces the electric field in the surrounding space.
- Can be a point charge, or a continuous distribution (sheet, sphere).
- Remains fixed in its location.



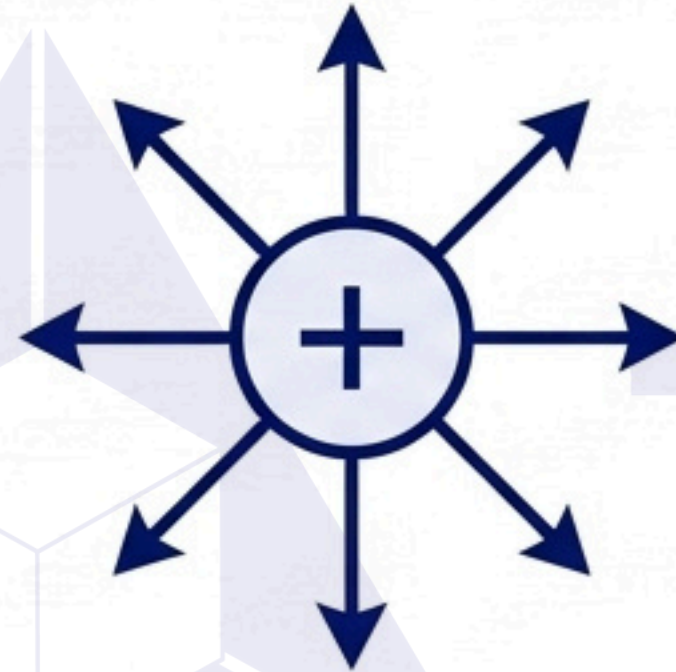
Test Charge (q_0)

- The "Detector"
- Experiences the force due to the existing field.
- Must be an idealized, infinitesimally small positive charge.
- Does not disturb the source charge.

Direction & Symmetry Around a Point Charge

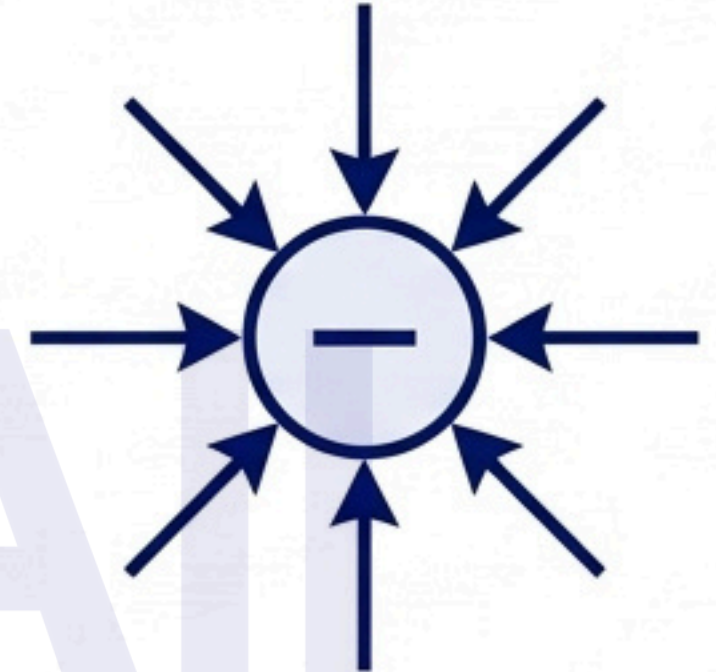
Positive Source (+Q)

Field points radially outward (the direction a positive test charge would be pushed).



Negative Source (-Q)

Field points radially inward (the direction a positive test charge would be pulled).



Spherical Symmetry

Because E depends only on the distance (r), the field magnitude is identical at all points on an imaginary sphere drawn around the point charge.

Check Your Understanding



The electric field is an elegant way to map the electrical environment created by a source charge, **completely independent** of the test charge used to measure it.

If the test charge q_0 is doubled, what happens to the Electric Field ($\mathbf{E}$) produced by source Q at that point?

Remains unchanged. $\mathbf{E}$ is a property of Q , not q_0 .

Why do we conventionally use a positive test charge?

So the direction of the force ($\mathbf{F}$) and the field ($\mathbf{E}$) are the exact same.



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