PHY-112 | Principles of Physics-2

Akiful Islam (AZW)
Summer 2024 | Class #3

Department of Mathematics & Natural Sciences

Recall the Electric Field Definition

Electric Field Intensity

Just the magnitude part

Electric Field $\vec{E}$ [N C^{-1} or V m^{-1}] is defined as the force per unit positive charge exerted on the test charge.

$$\begin{aligned}\vec{E} &= \lim_{q_0 \to 0} \frac{\vec{F}}{q_0} \\ &= \left(\frac{1}{4\pi\epsilon_0}\frac{|q|}{r^3}\right)\vec{r} \\ &= \left(\frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2}\right)\hat{r},\end{aligned}$$

Note: The limit is there to ensure the existence of the field even in the absence of Q. The field remains the same if the sources remain the same.

Electric Field Direction

Just the direction part

The direction of the electric field at a given point is **the direction in which a positive test charge would experience a force if placed at that same point** around the source charge that made the field.

$$\vec{F}_E = q_0 \vec{E},$$

where $\vec{F}_E \rightarrow$ Coulomb force felt by the observer charge q_0 in presence of $\vec{E}$. The field is produced by charge q.

Remember, q_0 did not make this $\vec{E}$. q_0 only measures its effect.

Incepting Ideas (1)

Hint: Use the field formula for point charges

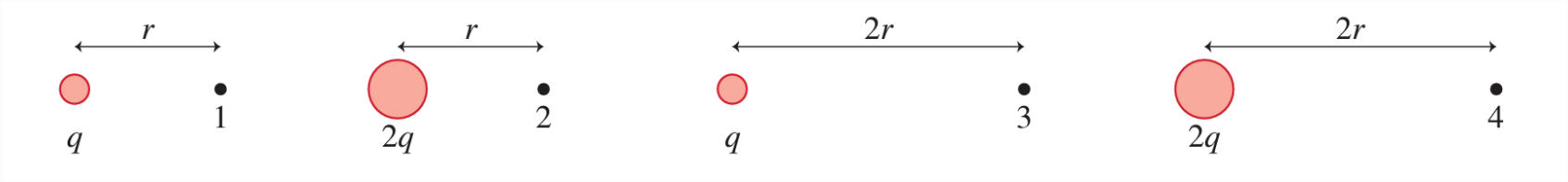
Q: Two charged particles are fixed on an x axis: $q_- = -3.20 \times 10^{-19}$ C at $x = -3.00$ m and $q_+ = 3.20 \times 10^{-19}$ C at $x = +3.00$ m.

What are the (a) magnitude and (b) direction (relative to the positive direction of the x axis) of the net electric field produced at point P at $y = 4.00$ m? (c) In what direction and magnitude will an electron accelerate if it were released from rest at P?

Incepting Ideas (2)

Hint: Use the field formula for point charges

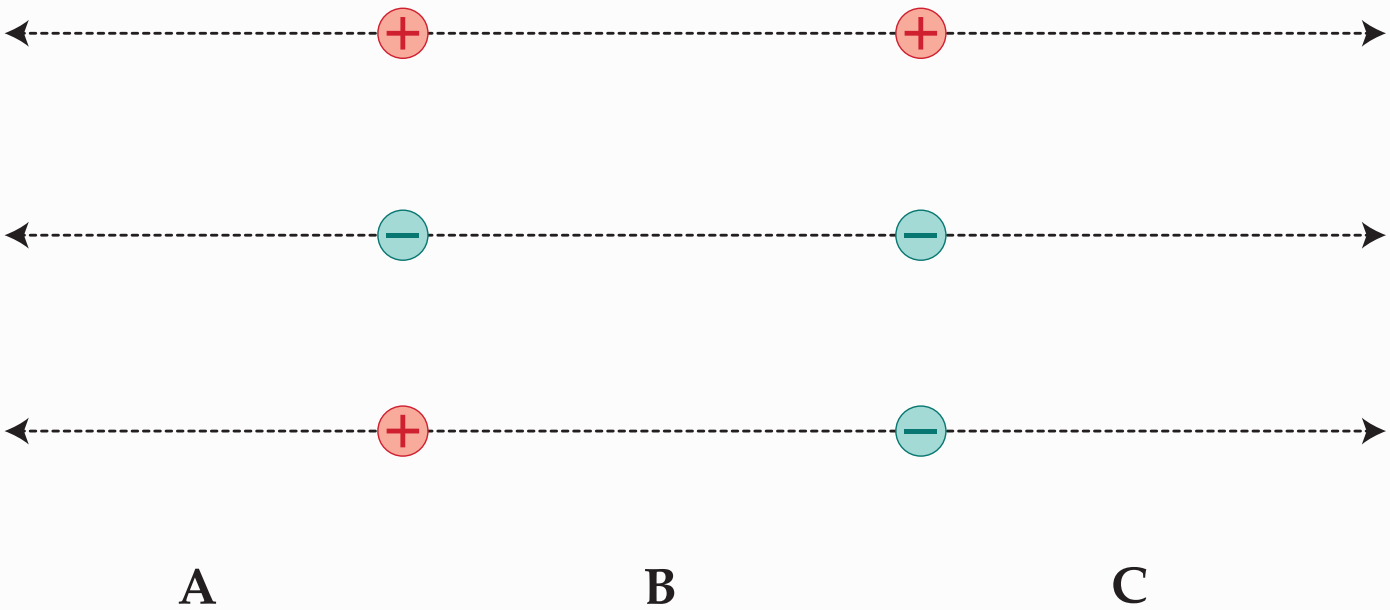
Q: Rank in order, from largest to smallest (descending order), the electric field strengths E_1 to E_4 at points 1 to 4. Try the same in an ascending order.



Incepting Ideas (3)

Hint: Condition for field cancellation

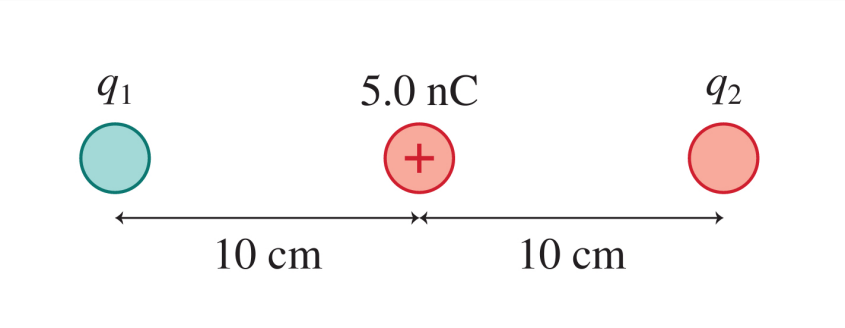
Q: Find the zero field and force region for any observer charge (positive or negative) other than at infinity.



Incepting Ideas (4)

Hint: Force cancellation

Q: q_2 is in equilibrium. What is q_1? What type?



Perspective Check

Our Journey So Far...

...into the real of Electric Fields

Electric Fields

- Q: What makes them? $\longrightarrow$ A: Electric Charge

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- Q: How to measure it? $\longrightarrow$ A: $\dfrac{\text{Coulomb Force}}{\text{Observer Charge}}$

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...into the real of Electric Fields

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- Q: What does it do to observers? $\longrightarrow$ A: Applies Coulomb Force
- Q: How to measure it? $\longrightarrow$ A: $\dfrac{\text{Coulomb Force}}{\text{Observer Charge}}$
- All were shown using Discrete Source cases

One Problem Solving Strategy to Rule them All
One strategy to bind them

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One strategy to bind them

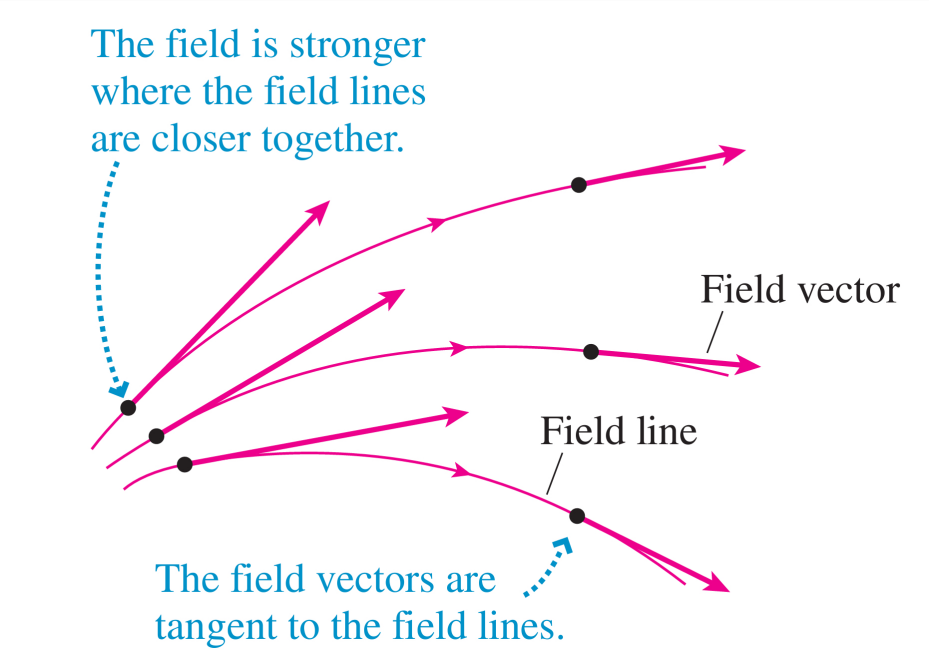
- The electric field/force of a point charge setup and
- The principle of superposition

How to *See* the Electric Field?

Electric Field Lines

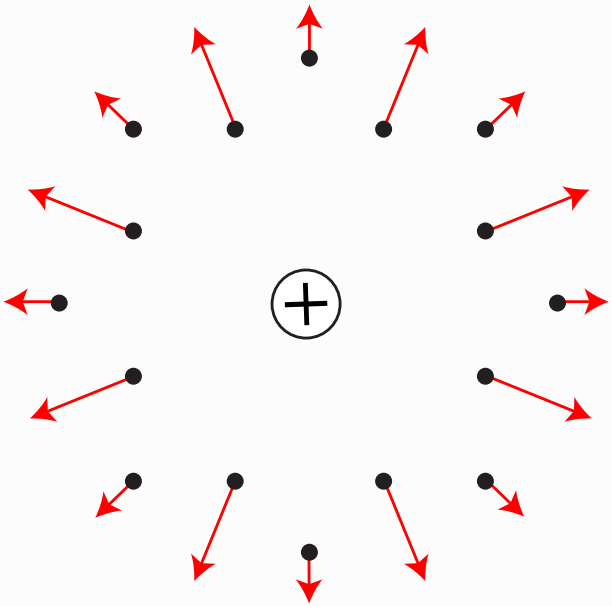
They are imaginary but the intuition is very real

- They are *continuous* curves tangent to the electric field vectors
- Closely spaced field lines indicate a greater field strength; widely spaced field lines indicate a smaller field strength
- They start on positive charges and end on negative charges and no two electric field lines will intersect

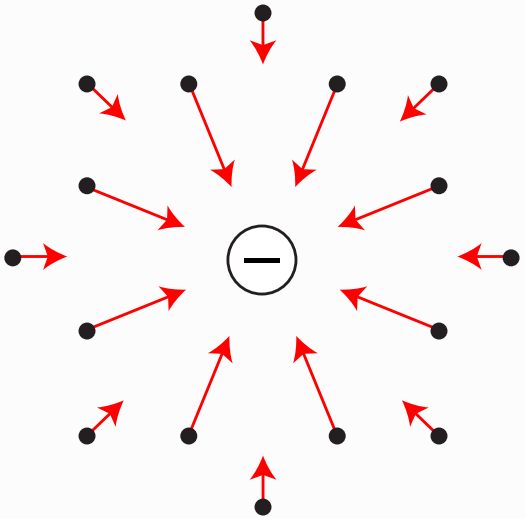


Electric Field due to a Charged Particle

Think 3D. Radially means across the radius of an imaginary sphere



Radially Outward



Radially Inward

That is it for today!