ELECTRICITY DAY 5: SUPERPOSITION - NET FORCE IN 2D

CED 10.1 · Skill 2.B · FRQ: MR · target: electric forces add as vectors, not unsigned magnitudes

PREDICT BEFORE CALCULATING

A positive target charge sits at the origin. Equal positive source charges sit at $(-0.30\ \text{m}, 0)$ and $(0, +0.30\ \text{m})$. Predict the net-force direction on the target: **NE / NW / SE / SW / zero**.

SUPERPOSITION PROCEDURE

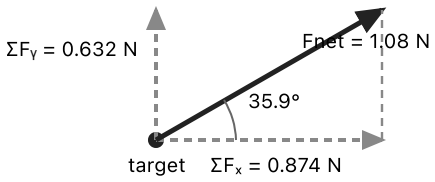
1. Choose the target charge.
2. Draw one force arrow on the target for each source charge.
3. Calculate each force magnitude with Coulomb's law.
4. Resolve angled forces into x- and y-components.
5. Add signed components: ΣF_x, ΣF_y.
6. Find $F_{\text{net}} = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$ and $\theta = \tan^{-1}(\Sigma F_y / \Sigma F_x)$, then place the angle in the correct quadrant.

QUICK Explain the warmup direction using force arrows only; no calculation is needed.

PERPENDICULAR CONTRIBUTIONS

WE DO A $+2.5\mu\text{C}$ target is at the origin. A $+3.5\mu\text{C}$ source is at $(-0.30\text{ m}, 0)$; a $-4.5\mu\text{C}$ source is at $(0, +0.40\text{ m})$. Find the net force on the target, including direction.

COMPONENT STRUCTURE - COPY LABELS ONTO YOUR SKETCH



Force contributions are perpendicular, so they become the signed x- and y-components of the resultant.

Use $\tan^{-1}$ to find a reference angle; the signs of ΣF_x and ΣF_y determine the quadrant.

SYMMETRY BEFORE ARITHMETIC

Symmetry can make components cancel exactly. For two equal sources placed as mirror images across an axis, components perpendicular to that axis often cancel while components along the axis add.

YOU DO Two equal positive charges sit at $(-0.25\ \text{m}, 0)$ and $(+0.25\ \text{m}, 0)$. A positive target is at $(0, +0.20\ \text{m})$. Draw both forces, identify the cancelling components, and state the net-force direction.

COMPARE If the right source charge is doubled while positions stay fixed, which component no longer cancels? Predict the direction of the new net force.

Efficiency rule: use symmetry to set a component to zero before calculating. Do not calculate two equal numbers just to subtract them.

PRACTICE

1. A $+2.2\mu\text{C}$ target is at $x = 0$. A $+4.4\mu\text{C}$ source is at $x = -0.25\text{m}$, and a $-3.3\mu\text{C}$ source is at $x = +0.35\text{m}$. Find the net force on the target.

2. A $-2.4\mu\text{C}$ target is at the origin. A $+3.6\mu\text{C}$ source is 0.30m left; a $-4.8\mu\text{C}$ source is 0.40m below. Find the net force magnitude and direction.

3. Four equal positive source charges occupy the corners of a square. State the net force on an identical target charge at the square's center and justify using symmetry.

4. A net force has components $F_x = -0.72\text{N}$, $F_y = +0.54\text{N}$. Find magnitude and direction measured counterclockwise from +x.