ELECTRICITY DAY 2: COULOMB'S LAW

CED 10.1 · Skill 2.B · FRQ: MR · target: inverse-square scaling and third-law force pairs

RETRIEVAL + PREDICTION

Two charged spheres remain unchanged while their center-to-center separation doubles from r to $2r$. Circle the new force factor before calculating:

×$1/2$ **×$1/4$** **×2** **×4**

THE ELECTRIC FORCE LAW

$$F = k\frac{|q_1 q_2|}{r^2} \qquad k = 8.99 \times 10^9 \text{N}\cdot\text{m}^2/\text{C}^2$$

- The equation above gives magnitude. Direction lies along the line joining the charges.
- Like signs repel; unlike signs attract.
- r is center-to-center separation in meters. Charges must be in coulombs.

DIRECTION CHECK For each pair, draw the force on each charge: (a) $+, +$ (b) $+, -$ (c) $-, -$. Use equal arrow lengths within each pair.

DIRECT CALCULATION

WE DO Charges $+2.5\mu\text{C}$ and $-4.5\mu\text{C}$ are 0.30m apart. Find the magnitude and describe the direction of the force on each charge.

YOU DO Charges $+3.5\mu\text{C}$ and $+5.5\mu\text{C}$ are 0.40m apart. Find the force magnitude and direction on each.

Magnitude first, direction second: use absolute charge magnitudes in the calculation, then use the signs and geometry to assign directions.

RATIO REASONING

When both charges and the separation change, compare the new force with the old force:

$$\frac{F_{\text{new}}}{F_{\text{old}}} = \frac{|q_{1n}|}{|q_{1o}|}\frac{|q_{2n}|}{|q_{2o}|}\left(\frac{r_o}{r_n}\right)^2$$

WE DO One charge doubles, the other is halved, and the separation triples. Find $F_{\text{new}}/F_{\text{old}}$.

YOU DO One charge becomes 1.5 times as large, the other is unchanged, and the separation is halved. Find the new-force factor.

THIRD-LAW PAIR

Coulomb's equation is symmetric in q_1 and q_2. The interaction gives equal-magnitude, opposite-direction forces even when the charge magnitudes differ. Different masses or charges may produce different accelerations; they do not change the equality of the force pair.

PRACTICE

1. Charges $+2.8\mu\text{C}$ and $-6.2\mu\text{C}$ are 0.35m apart. Find the force magnitude and direction on each.

2. Charges $2.2\mu\text{C}$ and $4.2\mu\text{C}$ exert a 1.50N force. Find their separation.

3. A $3.2\mu\text{C}$ charge and an unknown charge are 0.28m apart and exert a 1.10N force. Find the unknown charge magnitude.

4. Both charge magnitudes triple while the separation doubles. Find the force factor.

5. A $+2.0\mu\text{C}$ charge attracts a $-7.0\mu\text{C}$ charge. Which charge feels the larger force? Explain without calculating.