Invisible Force, Clear Pattern

Model how charge and distance affect electric force.

P.6.a "Develop and use a model to describe the mathematical relationship among charge, distance, and force as expressed by Coulomb's law."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the model equation, circle its charge and distance symbols, and draw arrows between table rows that show a charge change and a distance change.

Two Beads, One Model

1. Two charged beads can push on each other without touching. To predict that push, imagine beads so small that their sizes hardly matter compared with the gap between them. Model each bead as a point charge. Let r be their center-to-center separation, and let F be the force magnitude on either bead.

2. Coulomb's law gives the model $F = k|q_1q_2|/r^2$. Here q_1 and q_2 are charges; k is a constant for the surrounding medium. The table uses one fixed unit for each charge and for distance. Force is relative to the first row, F_0. If the charge product doubles at fixed distance, force doubles.

FORCE FOR TWO POINT CHARGES

$\lvert q_1 \rvert$ (units)	$\lvert q_2 \rvert$ (units)	r (units)	F/F_0
1	1	1	1
2	1	1	2
1	1	2	1/4
2	1	2	1/2
1	3	1	3

3. Distance has a different effect: doubling r makes the force one-fourth as large, not one-half. The equation gives magnitude, while the signs tell direction: like charges repel, and unlike charges attract. For two isolated beads, the forces have equal magnitudes and opposite directions. This point-charge model works best when the bead sizes are small compared with their separation.

2 ANSWER WITH EVIDENCE

Use the passage

1. Compare the first two table rows. How does changing $|q_1|$ change the force when everything else stays fixed?

2. Compare the first and third rows. Use the equation to explain why the force changes by that amount.

3. In the fourth row, one charge is doubled and the distance is doubled. How does the model produce the force shown?

4. Suppose the charges in the fourth row have opposite signs. What is the force magnitude relative to F_0, and do the beads attract or repel?

3 YOUR TURN

Your own words

Create a two-bead case not listed in the table, giving each bead a positive or negative charge with a magnitude of 1 to 4 units and choosing a distance of 1 to 3 units. Substitute your values into the model, find the force relative to F_0, and explain whether the beads attract or repel.

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PART 1 · READ AND MARK

Underline the model equation, circle its charge and distance symbols, and draw arrows between table rows that show a charge change and a distance change. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Compare the first two table rows. How does changing $\lvert q_1 \rvert$ change the force when everything else stays fixed?	**Doubling $\lvert q_1 \rvert$ from 1 to 2 doubles the force from F_0 to $2F_0$.**
2	Compare the first and third rows. Use the equation to explain why the force changes by that amount.	**The distance doubles, so r^2 becomes four times as large. The force falls from F_0 to $F_0/4$.**
3	In the fourth row, one charge is doubled and the distance is doubled. How does the model produce the force shown?	**The doubled charge multiplies force by 2, while the doubled distance divides it by 4. The result is $F_0/2$.**
4	Suppose the charges in the fourth row have opposite signs. What is the force magnitude relative to F_0, and do the beads attract or repel?	**The magnitude is $F_0/2$. The beads attract because their charges have opposite signs.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I choose $q_1 = 3^+$ units and $q_2 = 2^-$ units at r = 3 units. $F/F_0 = (3 \times 2)/3^2 = 2/3$. The beads attract because their charges have opposite signs.

Accept any case not listed in the table that uses the stated ranges. Check that the relative force equals the product of the charge magnitudes divided by the square of the distance, and that the attraction or repulsion matches the signs.