

ELECTRICITY DAY 10: ELECTRIC POTENTIAL ENERGY

CED 10.4 · Skill 2.C · FRQ: QQT · target: U may be positive or negative and follows $1/r$, not $1/r^2$

PREDICT

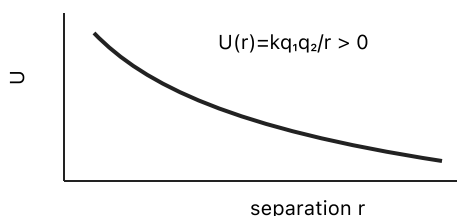
Two like charges are released from rest and move apart. Predict each change: U **increases / decreases / stays**; K **increases / decreases / stays**.

PAIR POTENTIAL ENERGY

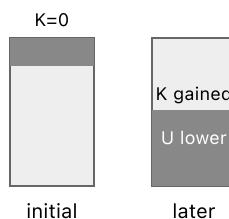
$$U = \frac{kq_1q_2}{r} \quad U = 0 \text{ at } r \rightarrow \infty$$

- Like charges: $q_1q_2 > 0$, so U is positive.
- Unlike charges: $q_1q_2 < 0$, so U is negative.
- U belongs to the charge-source system, not to one charge alone.

ELECTRIC POTENTIAL-ENERGY LANDSCAPE



RELEASED LIKE CHARGES



QUICK Sketch $U(r)$ for an unlike-charge pair on the same axes and label the zero reference.



CALCULATE U AND KEEP ITS SIGN**WE DO** Find U for $+2.5\mu\text{C}$ and $+1.5\mu\text{C}$ separated by 0.25m .**YOU DO** Find U for $+2.0\mu\text{C}$ and $-3.0\mu\text{C}$ separated by 0.30m . Interpret the sign relative to infinite separation.

Force is related to the slope of the energy graph:

$$F_r = -\frac{\Delta U}{\Delta r} \quad (\text{slope idea})$$

A $1/r$ energy curve has a $1/r^2$ force dependence.

ENERGY CONSERVATION

$$\Delta K = -\Delta U \quad K_i + U_i = K_f + U_f$$

WE DO Keep the $+2.5\mu\text{C}$ charge fixed. A $+1.5\mu\text{C}$, 0.020kg object is released from rest at $r_i = 0.25\text{m}$. Find its speed at $r_f = 0.45\text{m}$.

ASSEMBLING SEVERAL CHARGES

YOU DO Three charges have pair separations: $q_1 = +2.0\mu\text{C}$, $q_2 = -1.5\mu\text{C}$, $r_{12} = 0.30\text{m}$; $q_3 = +1.0\mu\text{C}$, $r_{13} = 0.40\text{m}$, $r_{23} = 0.50\text{m}$. Find total U by summing all three pairs.

PRACTICE

1. Find U for $-2.2\mu\text{C}$ and $-3.4\mu\text{C}$ at 0.40m .

2. Find U for $+1.8\mu\text{C}$ and $-2.6\mu\text{C}$ at 0.35m .

3. A fixed $+3.0\mu\text{C}$ charge repels a $+1.2\mu\text{C}$, 0.015kg object released at 0.20m . Find its speed at 0.50m .

4. Explain why an unlike-charge system can have negative U without having negative total energy in every situation.