ELECTRICITY DAY 11: ELECTRIC POTENTIAL & POTENTIAL DIFFERENCE

CED 10.5 · Skill 2.B · FRQ: MR · target: distinguish scalar V, system energy U, and vector field E

RETRIEVAL + PREDICTION

At one fixed point near source charges, a $+1\text{nC}$ test charge is replaced by $+4\text{nC}$. Predict whether the electric potential V at the point changes. Then predict whether U of the placed charge changes.

POTENTIAL IS ENERGY PER CHARGE

$$V = \frac{U}{q} \qquad V_{\text{point charge}} = \frac{kQ}{r}$$

V is a signed scalar set by source charges and location. The reference is $V = 0$ at infinite distance for isolated point charges.

Quantity	Meaning	Scalar/vector	Unit	Point-charge form
$\vec{E}$	force per positive test charge	vector	N/C	kQ/r^2
V	potential energy per charge	scalar	J/C = V	kQ/r
U	energy of charge-source system	scalar	J	$qV = kqQ/r$

QUICK For each phrase—N/C, J, J/C, direction required—identify E, U, or V.

SCALAR SUPERPOSITION

$$V_{\text{net}} = \sum_i \frac{kQ_i}{r_i}$$

Add signed numbers. No components or angles are needed.

WE DO Find V 0.30m from a $+2.5\mu\text{C}$ point charge.

YOU DO At point P, a $+2.0\mu\text{C}$ source is 0.25m away and a $-1.5\mu\text{C}$ source is 0.40m away. Find V at P.

PLACE A CHARGE A $-1.2\mu\text{C}$ charge is placed where $V = 7.49 \times 10^4\text{V}$. Find U.

POTENTIAL DIFFERENCE AND WORK

$$\Delta U = q\Delta V, \qquad W_{\text{field}} = -\Delta U, \qquad W_{\text{ext,slow}} = \Delta U$$

Here $W_{\text{ext,slow}}$ is the work by an external agent moving the charge slowly, so the kinetic-energy change is negligible.

WE DO A $+1.6\mu\text{C}$ charge moves slowly from $V_i = +20\text{kV}$ to $V_f = -15\text{kV}$. Find ΔV, ΔU, work by the electric field, and external work.

SIGN CHECK Repeat only the signs if the moved charge is negative.

PRACTICE

1. Find V 0.45m from a $-3.3\mu\text{C}$ source.

2. At P, $+1.8\mu\text{C}$ is 0.30m away and $-2.4\mu\text{C}$ is 0.50m away. Find V.

3. A $+2.2\mu\text{C}$ charge moves from 12 kV to 42 kV. Find ΔU, W_{field}, and quasistatic W_{ext}.

4. At a point where $V = 0$, must E also be zero? Use an equal (+)/(−) pair as evidence.