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Lecture: 15 (iq13)

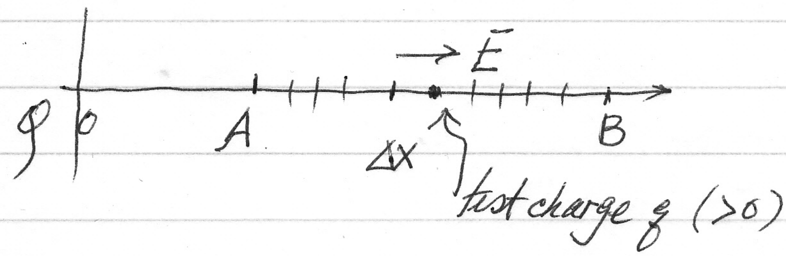
1. Review: Potential energy difference and potential difference due to a point charge.
2. V(r) for a uniformly charged plastic shell.
   Clicker **14-5**: Fig17.26 (Read: p681), plastic shell + plastic disk.
3. Sign of ΔV Clicker **15-1**: lifting vs free fall (range of the angle between E and Delta l)
4. ΔV in a non-uniform E region. clicker **15-2**, clicker **15-5**
5. ΔV within a uniformly charged rod. E=Cx (see **clicker ch17 h2:1-3**)
6. ΔV for general case, where $E=K/r^N$. (see clicker **ch17-h2:4-8**)

Announcement:

- My regular office hours: MWF 9:15-10:15. Other time by appointment iq 13

1. ΔU, ΔV due to pt charge.

- Let $Q>0$, placed at O. $\vec{E} = \frac{kQ}{r^2}\hat{r}$. Along x-axis



To move q to the left by Δx, need F_q^{ext} to counter balance F_q^{E}, $F_q^{ext} = -qE$. $\Delta U = F^{ext}\Delta x$

- Integration: $U_A - U_B = \sum_i (F^{ext}\Delta x)_i = \int_B^A F^{ext} dx$

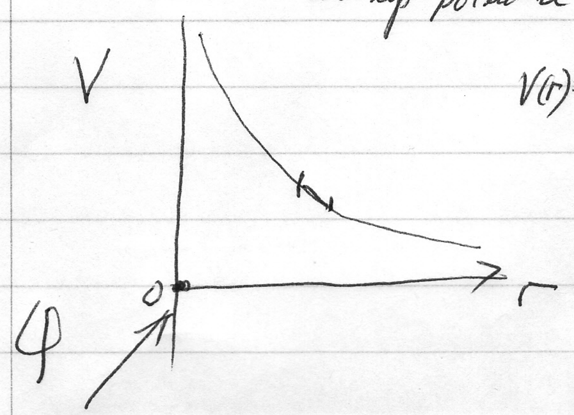
Let B at $r=\infty$, A at r, $U(r) - U(\infty) = \int_\infty^r (-qE)dx$

$$RHS = \int_\infty^x -q\frac{kQ}{x^2}dx = -qkQ\left(-\frac{1}{x}\right)\Big|_\infty^x = \frac{qkQ}{x}$$

$$\Delta V = \frac{\Delta U}{q} = \frac{kQ}{x} = V(x) - \underset{0}{\underset{\parallel}{V(\infty)}}$$

Point charge Q: Set up field: $\vec{E} = \frac{kQ}{r^2}\hat{r}$

Set up potential: $V = \frac{kQ}{r}$

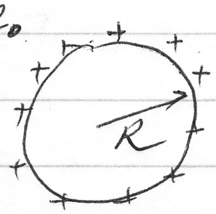


$V(r) = \left[\text{Work}/q\right]_{\infty \to r}$

$\Delta V = -E\Delta r$, $E = -\frac{\Delta V}{\Delta r}$.

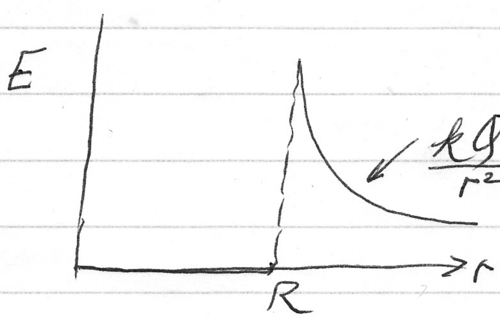
Check: $E \stackrel{?}{=} -\frac{\partial(kQ/r)}{\partial r} = \frac{kQ}{r^2}$.

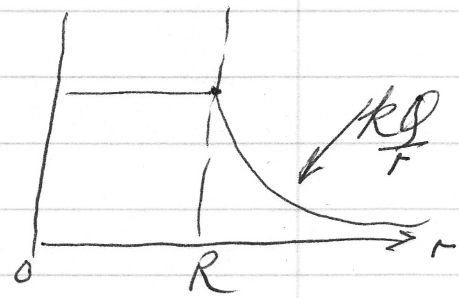
2. Uniformly charged shell, Q, R.



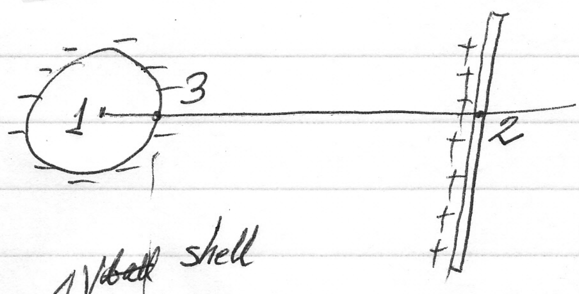
Find: $V(r)$ by inspection

$$\Delta V = -E\,\Delta x$$





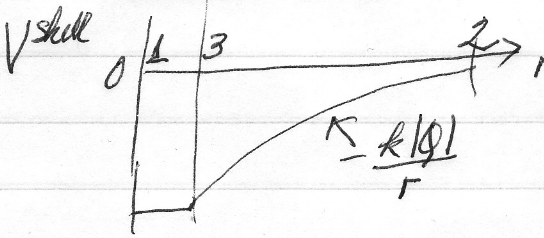
Clicker 14-5



Superposition:

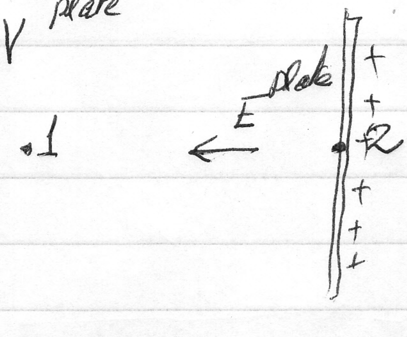
$$\Delta V \equiv V_2 - V_1 = \Delta V^{\cancel{\text{ball}}\ \text{shell}} + \Delta V^{\text{plate}}$$

$\underline{\Delta V^{\cancel{\text{ball}}\ \text{shell}}}$:



$\therefore\ \Delta V^{\text{shell}} = V_2^{\text{shell}} - V_1^{\text{shell}} > 0$

ΔV^{plate}



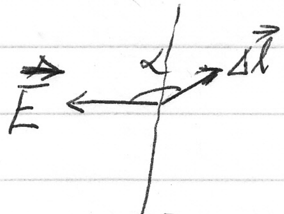
$\Delta V^{\text{plate}} > 0$

2. Clicker 15-1, Sign of $\Delta V \equiv V_B - V_A$ ← Uphill

$$\Delta V = -\vec{E}\cdot\Delta\vec{l} = -E\,\Delta l\cos\alpha \overset{180^\circ}{=} E\,\Delta l > 0.$$

Down hill: $V_A - V_B < 0$.

General case:



$\alpha > 90^\circ$, $\cos\alpha < 0$, $\Delta V >$

$\alpha < 90^\circ$, $\cos\alpha > 0$, $\Delta V < 0$

3. Nonuniform E : $\Delta V = -\vec{E}\cdot\Delta\vec{l} = V_B - V_A$

Clicker 15-2 Region I : $E = 300\ V/m$ → $\Delta l = 0.02\ m$ -6^V

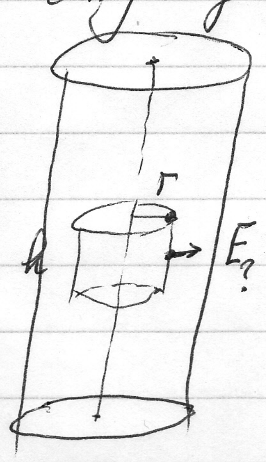
II : $E = 0$ 0^V

Work it III : $E = 300$ ← $\Delta l = 0.04\ m$ $+12^V$

$+6^V$.

$$\Delta V = \Delta V^{I} + \Delta V^{II} + \Delta V^{III}.$$

4. Uniformly charged rod :- Given : $\rho = \frac{\Delta Q}{\Delta vol} = \text{const}$



Gauss Law : $E_?\,(2\pi r h) = \frac{\rho\,\pi r^2 h}{\epsilon_0}$

$E_? = \frac{\rho\,\pi r^2 h}{\epsilon_0} \Big/ 2\pi r h = \text{const}\cdot r$

Clicker 17-A2:1-3

What is the sign of $V(R) - V(r)$? Ans.

+, 0, − (Downhill: −)

5. N-dependence of ΔV

We write the r-dependence of the field for various sources as $E = Kr^N$.

For dipole: $E = \frac{K}{r^3}$, or $N = -3$

point charge: $N = -2$

long rod: $N = -1$

solid rod: $r < R$, $N = +1$

The plot of E vs N is shown in the figure. Notice at $r=1$, $E = K$, independent of N. In going from $N = -3$ to $N = -$ the peak at $x = 0$ becomes less and less pronounced. At $N = +1$, the peak turns into a valley.

Consider the case $a = 0.5$ and $b = 1$. $\Delta V = V(0.5) - V(1$

How does ΔV vary with N ?

clicker 17-h2 4-8

Choices: As N increases

1. ΔV increases monotonically
2. ΔV = constant
3. ΔV decreases montonically
4. ΔV fluctuates as N increases

Hint: ΔV is related to the area under E curve from $x=0.5$ to $x=1$.