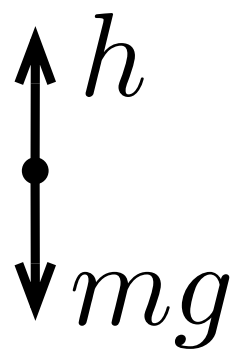


Lecture 14

Gravitational Potential Energy

Lift by h



A vertical line with a dot in the middle. An upward arrow is labeled h and a downward arrow is labeled mg .

$F^{lift} = mg, work = mgh$
(force against gravity)

Potential Energy Gain: $U = mgh$

When the ball is released, there is a downward acceleration over h

What is potential energy?

$\Rightarrow K = \frac{1}{2}mv^2$

Amount of work done to build up PE
Amount of K released

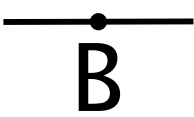


A

$$U_A - U_B = K_B - K_A$$

PE released KE gained

$$\Delta U = -\Delta K$$



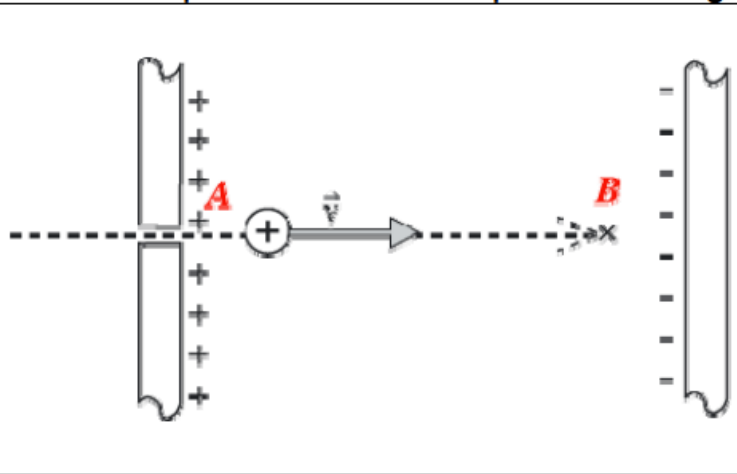
B

$$K_A + U_A = K_B + U_B = const. \quad (\text{total energy is constant})$$

$$\Delta K = -\Delta U$$

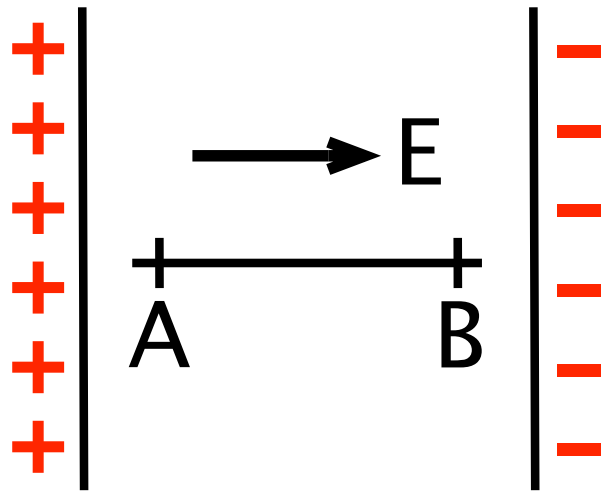
Consider the setup shown in Q16.1a: a positively charged particle q is accelerated by a constant electric force $F = qE$ over a distance $\Delta l = x_B - x_A$. Here the change of the kinetic energy is due to the work done by the electric force. The change of the potential energy is defined by the work done against electric force $\Delta U = U_B - U_A = -qE \cdot \Delta l$.

Q16.1a A proton enters a capacitor through a tiny hole. System: everything E: downhill



Which is true?

- 1) $\Delta K = 0$ and $\Delta U = 0$
- 2) $\Delta K < 0$ and $\Delta U > 0$
- 3) $\Delta K > 0$ and $\Delta U < 0$
- 4) $\Delta K > 0$ and $\Delta U > 0$
- 5) $\Delta K < 0$ and $\Delta U < 0$



Force due to E on q (down hill)

$$\vec{F}_q^E \xrightarrow{q>0} q\vec{E} \quad \text{to the right}$$

Δl : pushing from B to A (up hill)

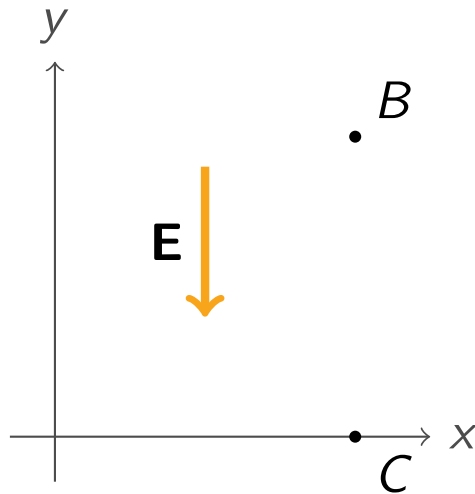
work against E: $(-qE) \cdot \Delta l$



$\therefore$ Climbing up potential hill, building up Potential Energy

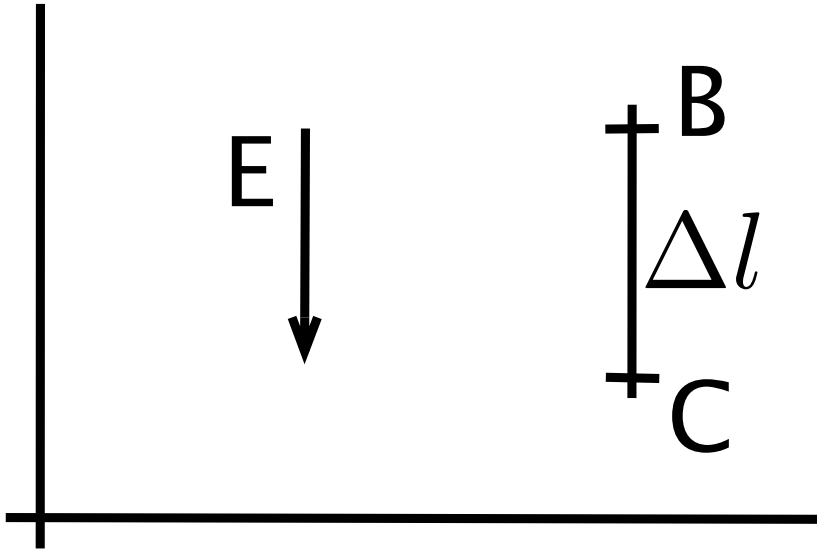
Potential:
$$\Delta V = \frac{\Delta U}{q} = -\vec{E} \cdot \Delta \vec{l}$$

Q16.3a: In a region of space, the electric field is uniform and given by $\mathbf{E} = \langle 0, -300, 0 \rangle \text{ N/C}$. If point B is at $\langle 2, 2, 0 \rangle \text{ m}$ and C is at $\langle 2, 0, 0 \rangle \text{ m}$, what is ΔV along a path from B to C ? (Recall that electric potential difference is defined by $\Delta V = \Delta U/q = -\mathbf{E} \bullet \Delta \mathbf{l}$.)



1. +150 V
2. -150 V
3. +300 V
4. -300 V
5. +600 V
6. -600 V

Fig(clicker) 14.3



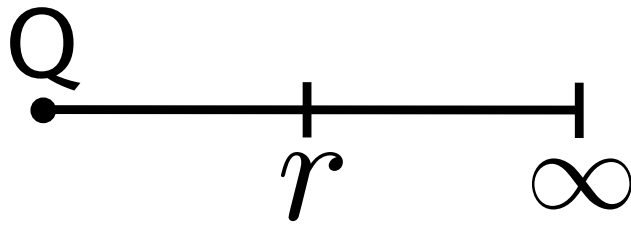
$$B \rightarrow C : \Delta V < 0$$

$$\Delta V = -\vec{E} \cdot \Delta \vec{l} < 0$$

Solution: (Downhill)

$$\Delta V = -[\langle 0, -300, 0 \rangle \cdot \langle 0, -2, 0 \rangle] = +300 \times (-2) = -600$$

Potential Due to a Point Charge

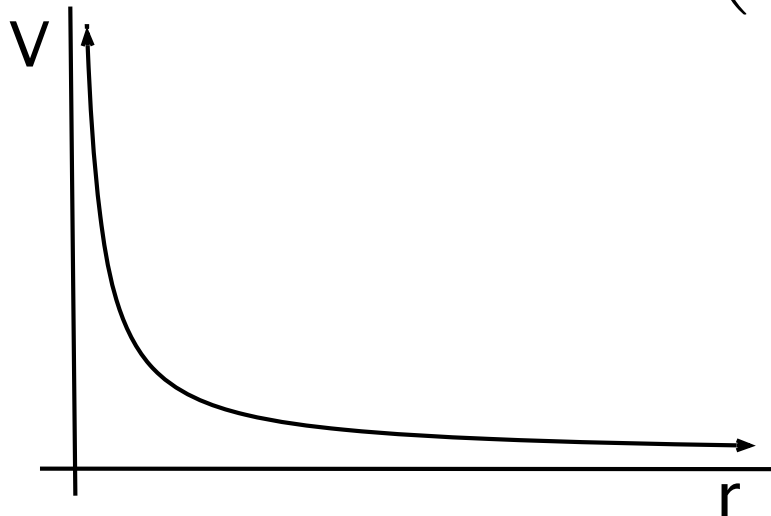


Find: $V(\infty) - V(r)$

$$\Delta V = -\vec{E} \cdot \Delta \vec{r}$$

$$V(\infty) - V(r) = - \int_r^\infty \frac{kQ}{r^2} dr$$

$$= -kQ \left(-\frac{1}{r} \right) \Big|_r^\infty = \frac{kQ}{r} \Big|_r^\infty = -\frac{kQ}{r}$$



$$V(\infty) = 0, \quad V(r) = \frac{kQ}{r}$$

From Potential to Electric Field

$$\Delta V = -\vec{E} \cdot \Delta \vec{l} = -E_x \Delta x - E_y \Delta y$$

$$E_x = -\frac{\Delta V}{\Delta x} = -\frac{\partial V}{\partial x}$$

$$V(x) = \frac{kQ}{x}$$

$$E_x = -\frac{\partial V}{\partial x} = -kQ \left[-\frac{1}{x^2} \right] = \frac{kQ}{x^2}$$

Fig(clicker) 14.5

Consider ΔV due to the field of a charged disk and a charged shell.

the set up shown in in Fig. 17.26 — a uniformly charged plastic shell and a uniformly charged glass disk are separated by a distance d . Determine the sign of $V_2 - V_1$.

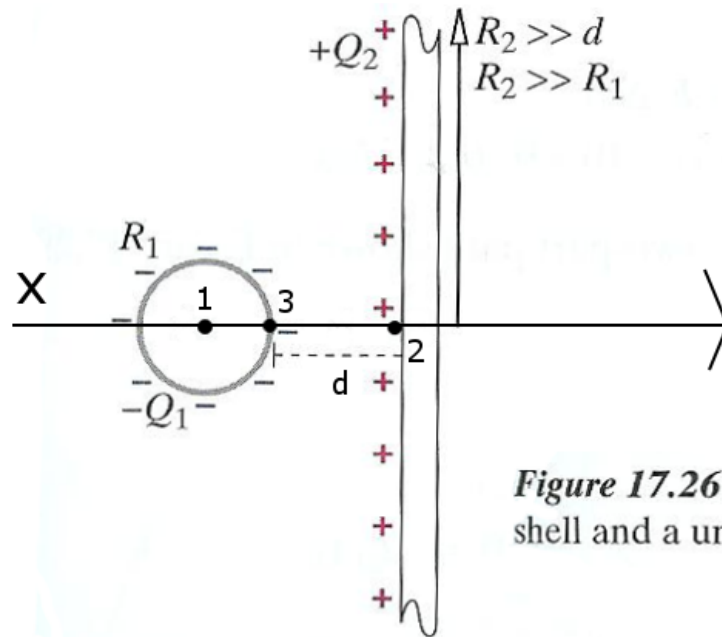
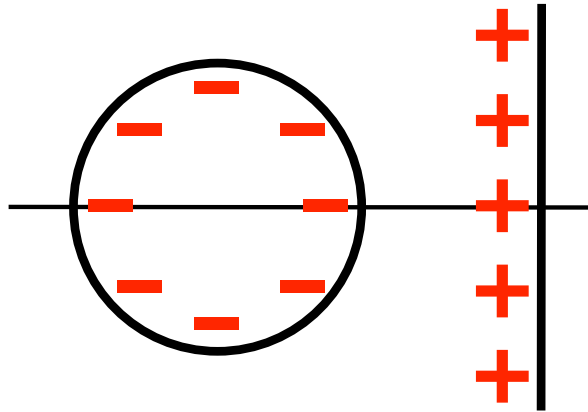


Figure 17.26 A uniformly charged plastic shell and a uniformly charged glass disk.

Choice	Sign of $V_2 - V_1$
1	> 0
2	$= 0$
3	< 0

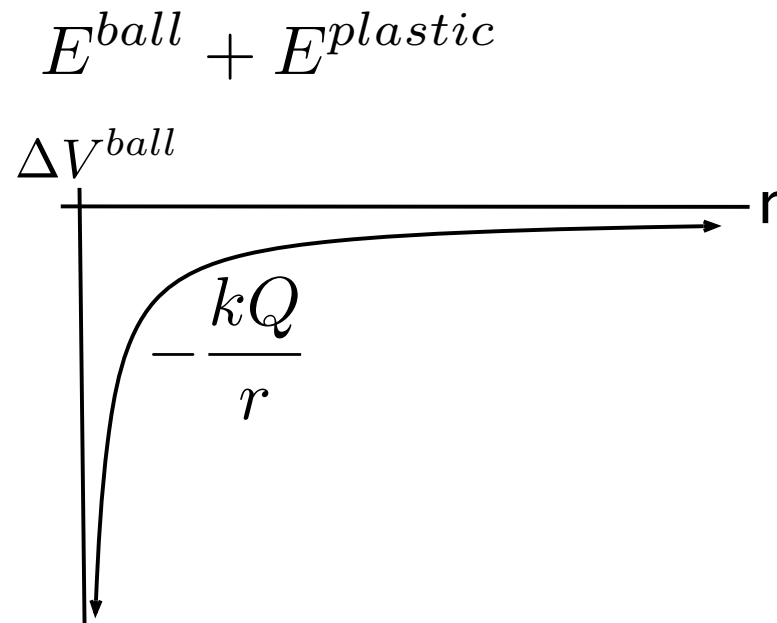
Explanation:



Find the sign of $V_2 - V_1$

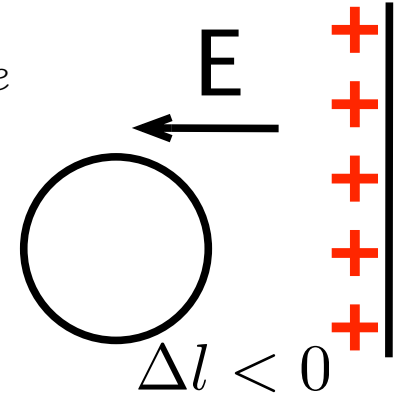
SS Principle:

$$V_2 - V_1 = (V_2 - V_1)^{plate} + (V_2 - V_1)^{ball}$$



$$(V_2 - V_1)^{plate}$$

$$E^{plate} \leftarrow$$



$$V_2^{ball} - V_1^{ball} > 0$$