Announcements

- Homework
  - You have Webwork due tonight
  - Nothing due Friday or next Monday
- Test on Friday!
  - Bring your notecard and calculator!
  - Will get a few minutes at the start to talk it over with neighbors
- Polling: `rembold-class.ddns.net`

Review Question

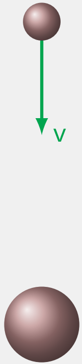
The proton to the right is initially traveling towards the positive 5 nC charge at a rate of 500 m/s. It comes to a stop a short distance from the charge. Taking both charges to be the system and assuming no external forces acting on the system, which of the below statements is true?

A) $\Delta U > 0$, $\Delta K < 0$

B) $\Delta U < 0$, $\Delta K > 0$

C) $\Delta U > 0$, $\Delta K > 0$

D) $\Delta U < 0$, $\Delta K < 0$



Solution: $\Delta U > 0$, $\Delta K < 0$

Slippery Slopes

- Some rearranging gives us

$$E_x = -\frac{\Delta V}{\Delta x}, \quad E_y = -\frac{\Delta V}{\Delta y}, \quad E_z = -\frac{\Delta V}{\Delta z}$$

- Or, for tiny displacements:

$$E_x = -\frac{\partial V}{\partial x}, \quad E_y = -\frac{\partial V}{\partial y}, \quad E_z = -\frac{\partial V}{\partial z}$$

- So the electric field in any direction is the negative slope of the potential in that direction!
- Alternative units for electric field: V/m

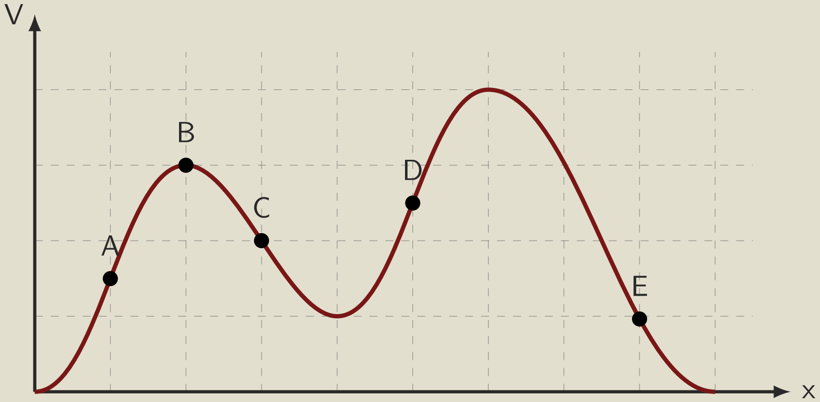
Finding ΔV

Suppose we have an electric field with a magnitude of $100\,\mathrm{N/C}$ pointing 40° above the positive x axis. What would be the change in potential moving from $\vec{\mathbf{r}}_i = \langle 1, 0, 0\rangle$ to $\vec{\mathbf{r}}_f = \langle 4, -2, 0\rangle$?

Solution: $-101.256\,\mathrm{V}$

Electric Field Directions

Given the plot of the electric potential below, determine the direction of the electric field at the listed points.



Solution: A) $\leftarrow$, B) 0, C) $\rightarrow$, D) $\leftarrow$, E) $\rightarrow$

Your Turn!

You are located at the point $\langle 1, 2, 2 \rangle$. If you move 1 mm in the positive x-direction, your electric potential drops by 300 V. If you move 1 mm in the negative y-direction, your electric potential drops by 150 V. What is the approximate electric field at your position?

A) $\langle 3 \times 10^5, -1.5 \times 10^5, 0 \rangle$ V/m
B) $\langle -3 \times 10^5, -1.5 \times 10^5, 0 \rangle$ V/m
C) $\langle 3 \times 10^2, 1.5 \times 10^2, 0 \rangle$ V/m
D) $\langle -3 \times 10^2, 1.5 \times 10^2, 0 \rangle$ V/m

Solution: $\left\langle 3 \times 10^5, -1.5 \times 10^5, 0 \right\rangle$ V/m

An Intuitive Understanding

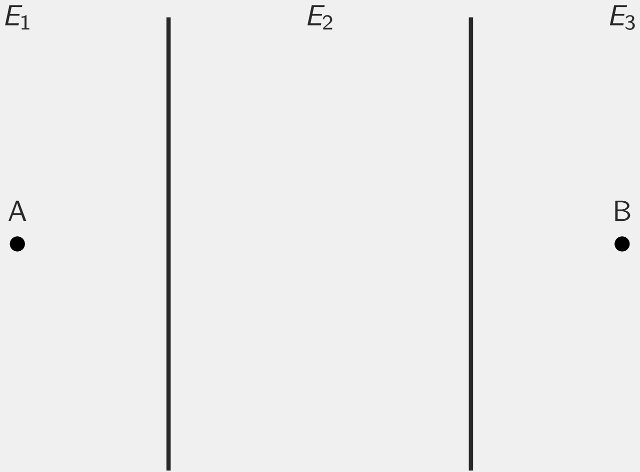
- Force and Electric Fields like to point "downhill"

$$F_x = -\frac{\partial U}{\partial x}, \quad E_x = -\frac{\partial V}{\partial x}$$

- Moving along an electric field means you are decreasing in potential ($\Delta V < 0$)
  - Moving "downhill"
- Moving opposite an electric field means you are increasing in potential ($\Delta V > 0$)
  - Moving "uphill"
- Moving perpendicular to an Efield results in no change in potential ($\Delta V = 0$)
  - Moving sideways along the hill

Non-Constant Electric Fields

- What do we do when the electric field is changing?



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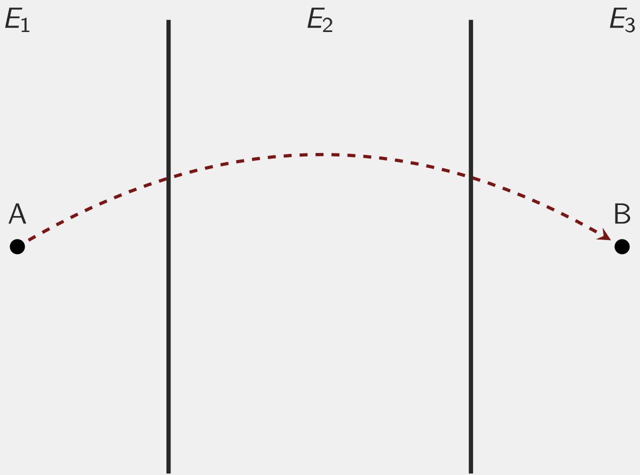

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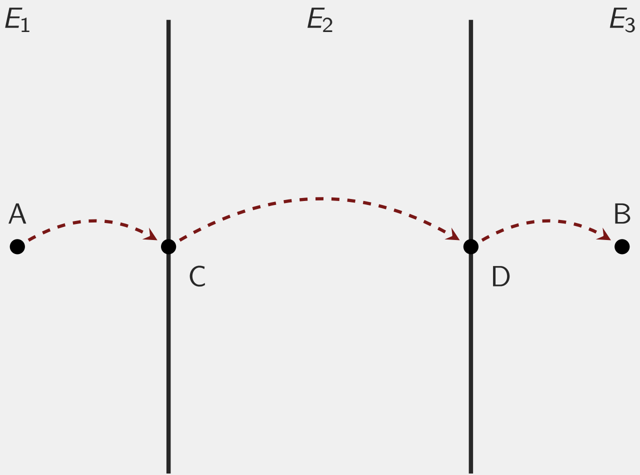

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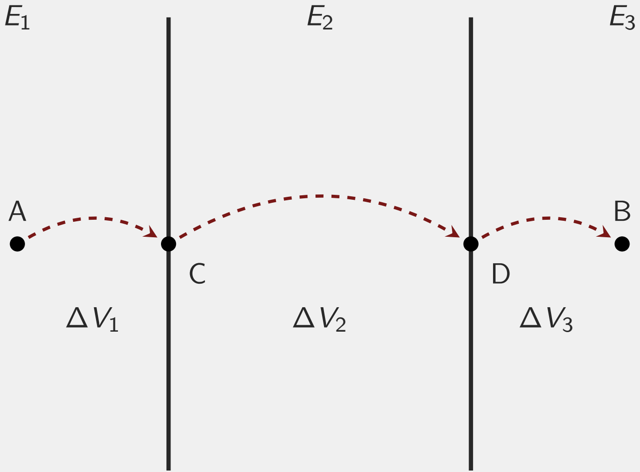


Putting it Together

- Total change it potential then from $A \to B$ is

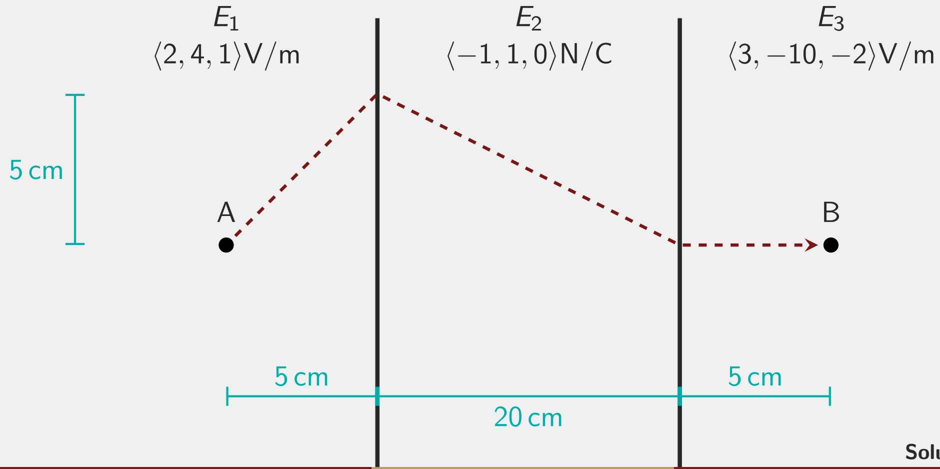
$$\Delta V_{AB} = \Delta V_1 + \Delta V_2 + \Delta V_3 = -\sum \vec{\mathbf{E}} \cdot \Delta\vec{\mathbf{l}}$$

- Can work for any set or series of different constant electric fields
- What if the electric field is constantly changing?
    - Example: $\frac{1}{r^2}$ dependence
    - Need to break into tiny chunks where the field is roughly constant
    - Adding those all up is the same as integrating

$$V_f - V_i = -\int_i^f \vec{\mathbf{E}} \cdot \mathrm{d}\vec{\mathbf{l}}$$

Group Work

What is the total change in electric potential from point A to point B along the path shown?



Solution: -0.2 V

Test Study Questions

Remaining time is left open for test prep questions or working on study questions