Announcements

- Homework
  - Online HW 9 due on Wednesday
- Still grading the Test. Expect results Wednesday probably
  - Seems it was definitely on the long side, so some points will probably be being added to try to compensate for that. Sorry!
- Lab this week on Potential Differences
- Polling: `rembold-class.ddns.net`

Suppose you are moving from point A to point B *along the indicated path*. What is the potential difference between A and B along that path?

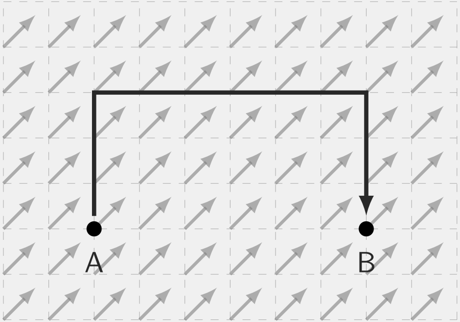
A. $-9\,\mathrm{V}$

B. $0\,\mathrm{V}$

C. $9\,\mathrm{V}$

D. $18\,\mathrm{V}$

$\vec{\mathbf{E}} = \langle 1.5, 1.5, 0 \rangle \mathrm{V/m}$



Today's Goals

- Voltage implications in conductors
- Integration
- Path dependence
- Single voltages

Voltage in Conductors

- When in equilibrium in conductor:

$$\vec{\mathbf{E}} = 0$$

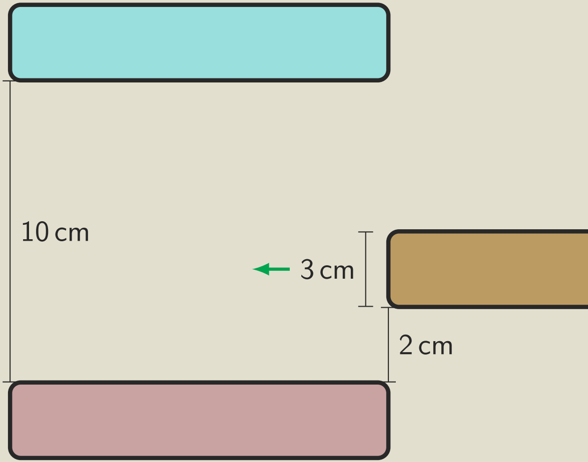
- Thus, no matter what path we choose inside a conductor in equilibrium:

$$\Delta V = -\sum \vec{\mathbf{E}} \cdot \mathrm{d}\vec{\ell} = 0$$

- Put otherwise, voltage is constant inside a conductor at equilibrium!

A Potential Conductor

The plates to the left are separated by 10 cm and have a potential difference of 10 V from one to the other. We insert a copper plate which is 3 cm tall and has a cross-sectional area equal to that of the plates as seen. What is the new potential difference from the top plate to the bottom?



Integrating to get Potential Differences

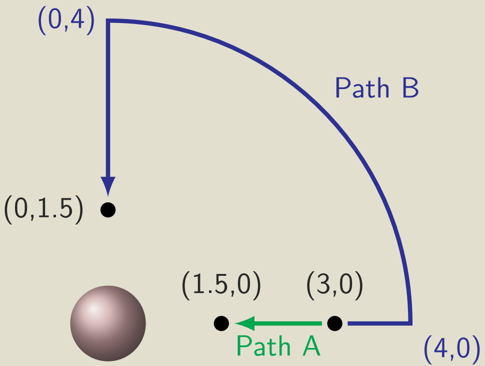
- If electric field is changing, need to split into approximately constant chunks and then add
- Infinitely tiny chunks $\Rightarrow$ Integration

$$\Delta V = -\int_i^f \vec{\mathbf{E}} \cdot \mathrm{d}\vec{\ell}$$

- Technically integration *along a line*, which can be tricky for curving lines
  - We'll stick to simple paths or ones that are easily added together

Integrating Paths

Suppose we have a point charge with $10\,\mu\text{C}$ of charge. What is the change in electric potential along the two paths shown below?

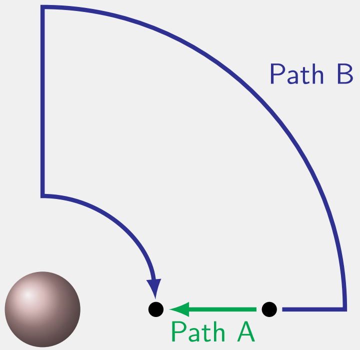


Path Independence

- Could have arced back to the end of Path A with no potential difference
- Would mean that the potential difference along the two different paths is the same!

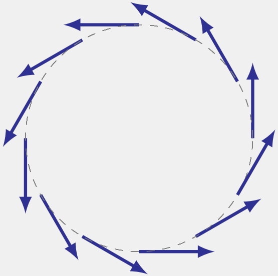
Path Independence

Like potential energy, the change in potential between two points is the same irrespective of the path followed!



Implications

- Choose the easiest path to find the potential difference
  - Usually means breaking up into the parallel and perpendicular parts
- Potential difference over a total round trip must equal zero
  - Otherwise, energy would not be conserved!
- Some electric field configurations are impossible from stationary charges



Understanding Check

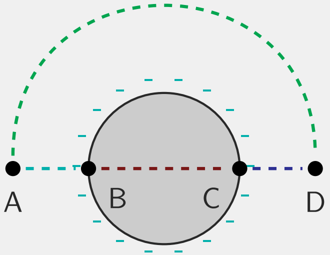
Given the charged conductor to the right, which of the following quantities are zero?

A. $V_C - V_A$

B. $V_B - V_C$

C. $V_B - V_A$ and $V_D - V_C$

D. $V_D - V_A$ and $V_B - V_C$



A Single Potential

- In the vast majority of cases, it is ΔV that we are interested in
- Occasionally can be useful to think about what a single potential might be though
  - Requires us to think about where we set the zero point
  - Define the zero point to be at infinity so that

$$V_A = V_A - V_\infty$$

  - Makes sense since, for a point charge:

$$V_\infty = \frac{1}{4\pi\epsilon_0}\frac{Q}{\infty} = 0$$

Simple Example

What is the electric potential 5 mm from a 20 nC point charge?

Dipole Potentials

Use two different techniques to calculate the potential due to a dipole with charge $2e$ and separation of $10\,\mathrm{nm}$ at a point $5\,\mathrm{cm}$ from the center of the dipole and perpendicular to its axis.