PHYS 301
Electricity and Magnetism

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Today!

- Electric fields
  - Electric potential
  - Conductors

Fundamental Equations of Electrostatics

$$\vec{\nabla} \cdot \vec{E} = \rho / \varepsilon_o \qquad \vec{\nabla} \times \vec{E} = 0$$

permits $\vec{E} = -\vec{\nabla} V$

- In terms of potential:

$$\Rightarrow \quad \vec{\nabla} \cdot (-\vec{\nabla} V) = -\nabla^2 V = \rho / \varepsilon_o$$

$$\nabla^2 V = -\rho / \varepsilon_o \quad \xrightarrow{\text{if } \rho = 0} \quad \nabla^2 V = 0$$

Poisson's equation — *LaPlace's equation*

Electric Potential

ELECTROSTATICS

- The workhorse of electric potential looks a lot like its electric field counter part:

$$V(\vec{r}) = \frac{1}{4\pi\varepsilon_o} \frac{q}{\mathscr{r}}$$

point charge

continuous charge distributions

$$V(\vec{r}) = \frac{1}{4\pi\varepsilon_o} \int \frac{\rho(\vec{r}\,')}{|\vec{\mathscr{r}}|} d\tau'$$

$$V(\vec{r}) = \frac{1}{4\pi\varepsilon_o} \int \frac{\sigma(\vec{r}\,')}{|\vec{\mathscr{r}}|} dA'$$

$$V(\vec{r}) = \frac{1}{4\pi\varepsilon_o} \int \frac{\lambda(\vec{r}\,')}{|\vec{\mathscr{r}}|} dl'$$

relative to what?

infinity!

Conductors

ELECTROSTATICS

- **Ideal conductors:** Material with unlimited supply of completely free electrons! [fiction]
- **Properties:**
  - $\vec{E} = 0$ inside a conductor.
  - $\rho = 0$ inside a conductor.
  - Any net charge resides on the outer surface
  - V is constant throughout a conductor.
  - $\vec{E}$ is normal to the surface just outside a conductor.
- **Charging by induction:** Electric fields can induce charge separation in a conductor