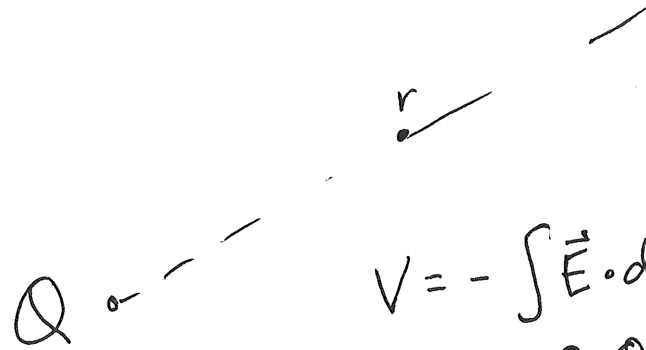
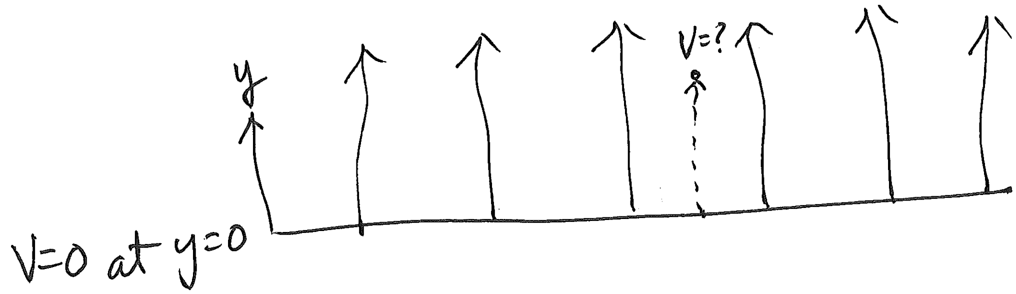


$$V = -\int \vec{E} \cdot d\vec{r}$$

$$= -\int \frac{Q}{4\pi\varepsilon_0} \cdot \frac{1}{r}\, dr.$$

If $V=0$ at ∞.

$$V = -\frac{Q}{4\pi\varepsilon_0} \cdot \frac{1}{r}.$$



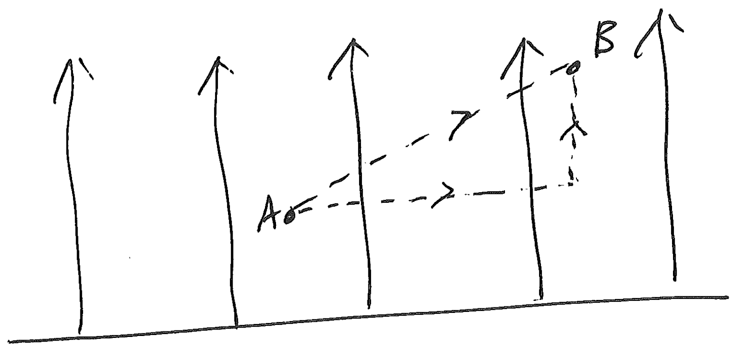
$$V = -\int \vec{E} \cdot d\vec{r}$$

$$= -\int E\, dy$$

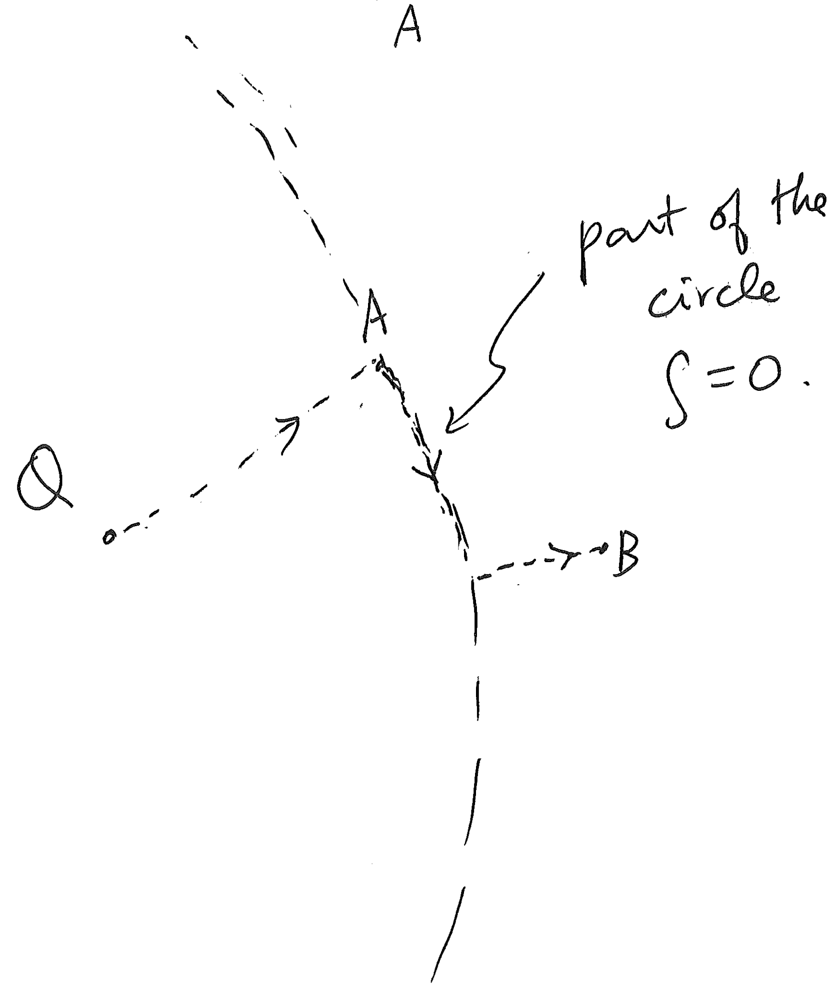
$$= -Ey + C.$$

$V=0$ at $y=0 \Rightarrow C=0$ $\quad \therefore V = -Ey.$

Potential difference.



$$V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{r}$$



Conservative force:

$$\nabla \times \vec{E} = 0.$$

($\nabla \times E = 0 \Rightarrow \oint \underbrace{(\nabla \times \vec{E})}_{0} \cdot d\vec{S} = \oint \vec{E} \cdot d\vec{r}$

Definition in differential form.

$\Rightarrow \oint \vec{E} \cdot d\vec{r} = 0 \leftarrow$ This class)

Def. of conservative force.

$$\nabla \times (-\nabla V) = 0.$$

$$\therefore E = -\nabla V \leftarrow \text{Definition of } V \text{ in differential form}$$

$$E = -\int \vec{E} \cdot d\vec{r} \leftarrow \text{This class.}$$

e.g. ∇ in polar coordinate:

$$\nabla = \frac{\partial}{\partial r}\hat{r} + \frac{1}{r\cancel{\sin\theta}}\frac{\partial}{\partial \theta}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial}{\partial \phi}\hat{\phi}$$

$$V = \frac{Q}{4\pi\varepsilon_0}\frac{1}{r}$$

$$-\nabla V = -\frac{\partial}{\partial r}\left(\frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{r}\right)\hat{r}$$

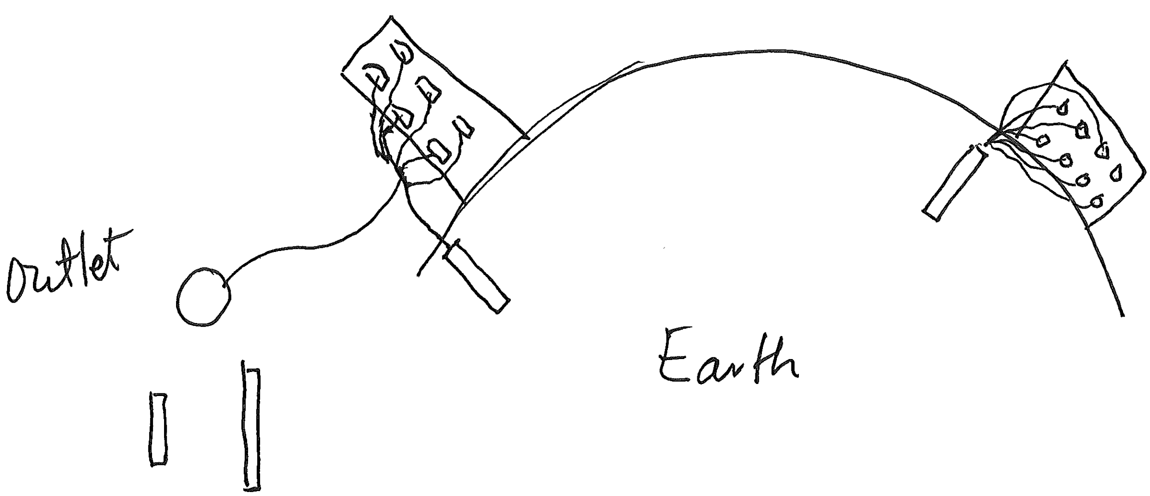
$$- \frac{1}{r}\frac{\partial}{\partial\theta}\left(\frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{r}\right)\hat{\theta} - \frac{1}{r\sin\theta}\left(\frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{r}\right)\hat{\phi}$$

$$\left(\begin{aligned} \nabla V &= \hat{x}\frac{\partial}{\partial x} + \hat{y}\frac{\partial}{\partial y} + \hat{z}\frac{\partial}{\partial z}. \\ V &= \frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{\sqrt{x^2+y^2+z^2}} \end{aligned}\right)$$

$$-\nabla V = \frac{-\partial}{\partial r}\left(\frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{r}\right)\hat{r}$$

$$= -\left(-\frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{r^2}\hat{r}\right)$$

$$= \frac{Q}{4\pi\varepsilon_0}\cdot\frac{1}{r^2}\hat{r} = \vec{E}.$$



$$\varepsilon_0 \oint \vec{E}\cdot d\vec{A} = Q.$$ ← ~~Out~~ Gauss's Law in ~~A~~ integral form (This class).

$\Phi = 0$ doesn't mean $E = 0$.

by Divergence theorem: $$\varepsilon_0 \underset{\oint \vec{E}\cdot dA}{\underset{\parallel}{\oint \nabla\cdot\vec{E}\, dV}} = Q.$$

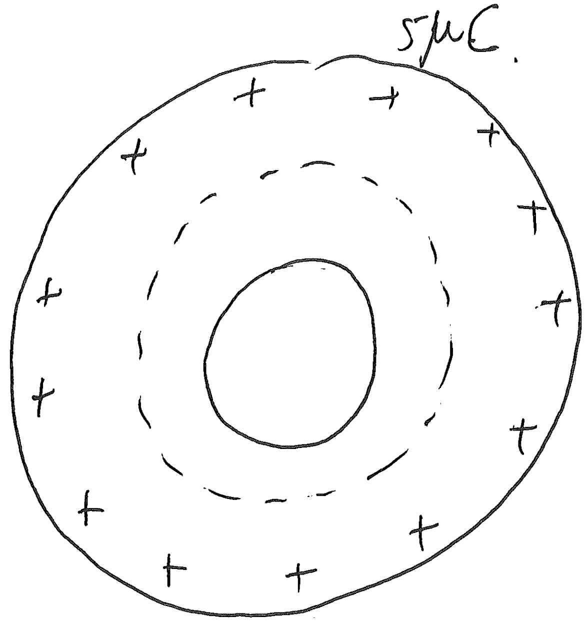
$$\Rightarrow \varepsilon_0 \nabla\cdot\vec{E} = \frac{dQ}{dV}$$

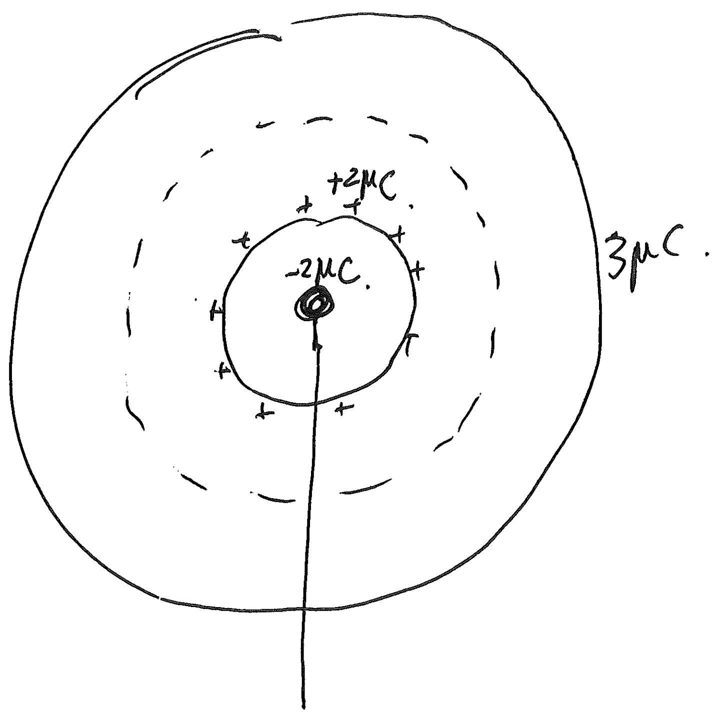
$$\Rightarrow \varepsilon_0 \nabla\cdot\vec{E} = \rho.$$ ← Gauss's Law in Differential form.

$$\left\{\begin{array}{l} \nabla\cdot\vec{E} = 0 \text{ Doesn't mean } \vec{E} = 0. \\ \vec{E} = -\nabla V. \end{array}\right.$$

$$\Rightarrow \nabla^2 V = \rho. \qquad (\nabla\cdot\nabla = \nabla^2).$$

Laplace Eq.


5μC.


+2μC.
-2μC.
3μC.