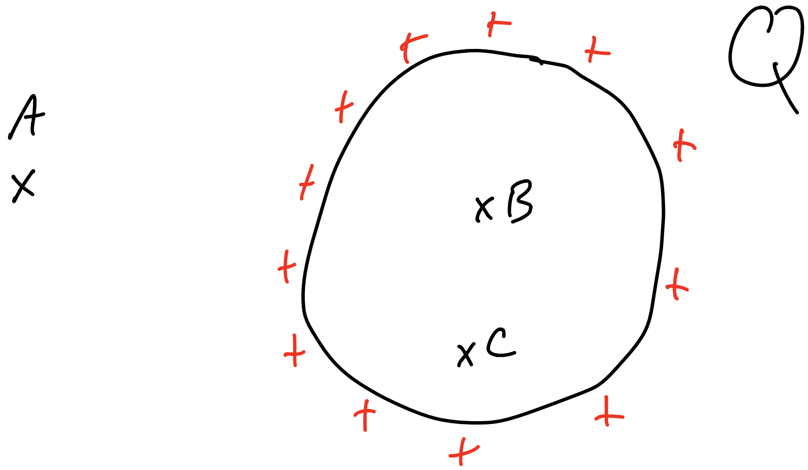
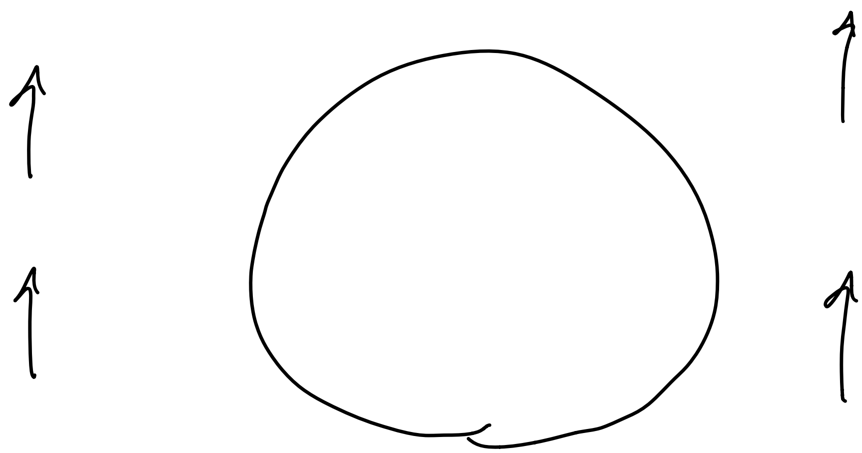


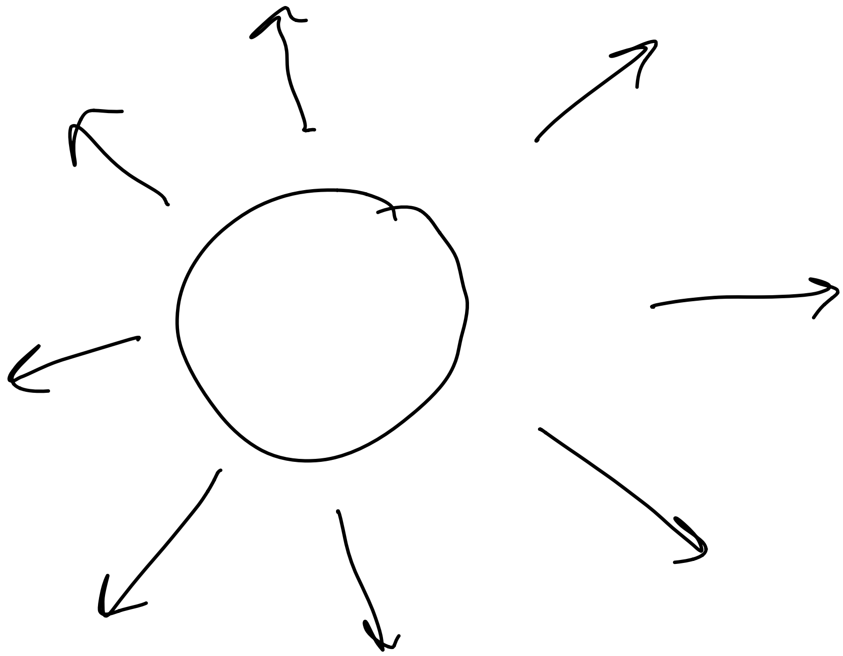
$\hat{\underline{E}}$ at A

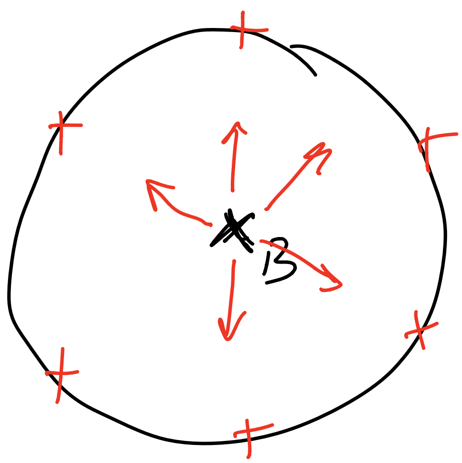
suppose

A is notradial

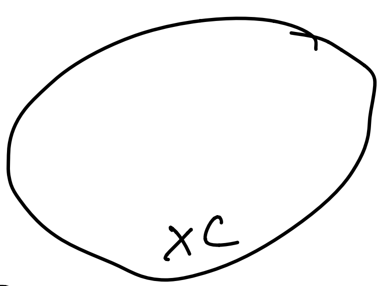


Not symmetric





= 0



= 0

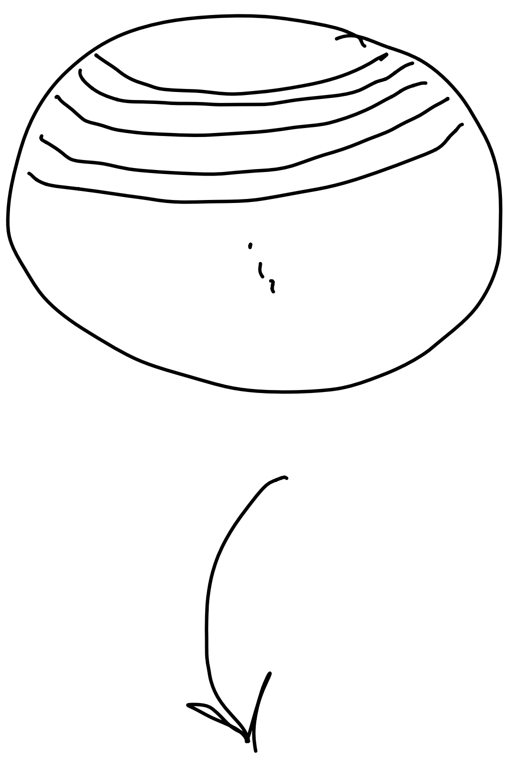
Jupyter

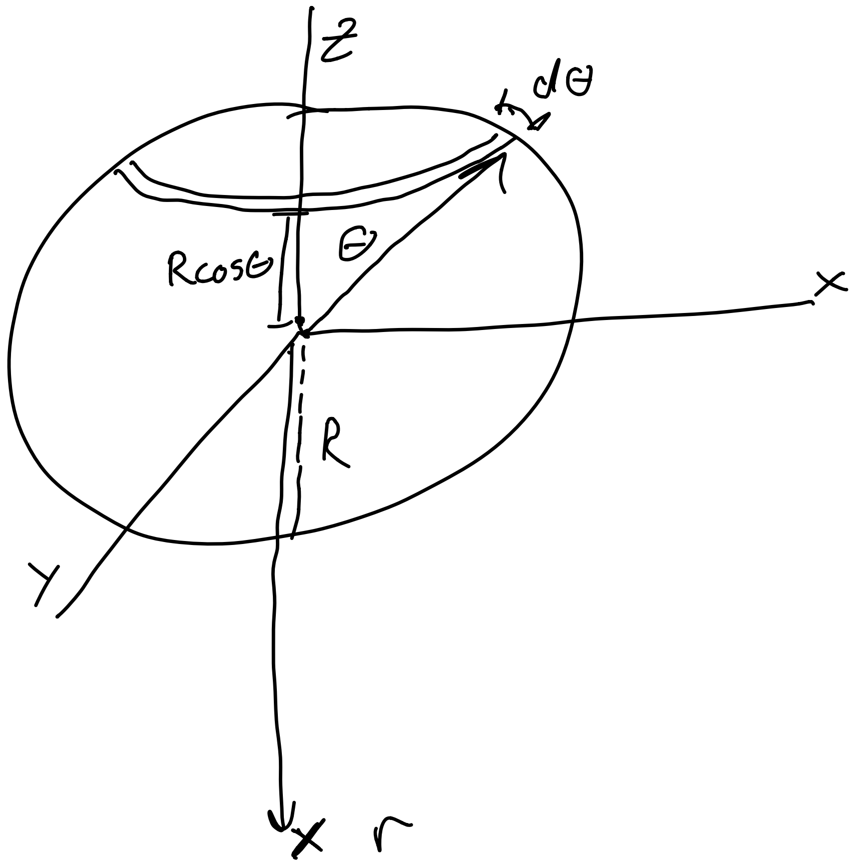
$$\vec{E}_{inside} = 0$$

$$\vec{E}_{outside} = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \hat{r}$$

Point Charge!

Another way





$$dE = \frac{k\,\Delta Q \quad z}{\left(R^2 + z^2\right)^{\frac{3}{2}}}$$

$$z = r + R\cos\theta$$

$$\text{charge dens} = \frac{Q}{4\pi R^2}$$

$$\Delta Q = \text{dens} \times A_{ring}$$

$$\downarrow$$

A_{ring}

$$\Delta Q = \frac{Q}{4\pi R^2} 2\pi R^2 \sin\Theta = \frac{Q}{2}\sin\Theta$$

$$dE = k\frac{Q}{2}\sin\Theta \frac{z}{(R^2+z^2)^{3/2}}$$

$$z = r + R\cos\Theta$$

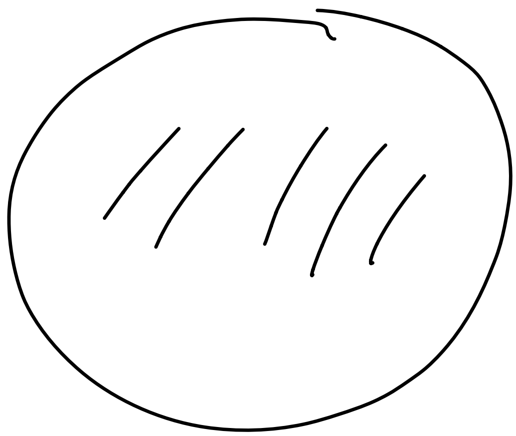
$$dE = \frac{kQ}{2}\frac{(r+R\cos\Theta)}{\left[R^2+(r+R\cos\Theta)^2\right]^{3/2}}\sin\Theta\, d\Theta$$

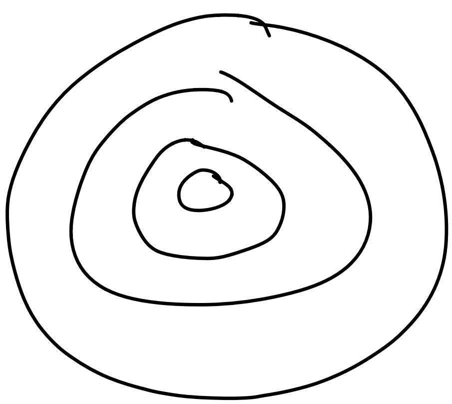
$$E = \frac{kQ}{2}\int_0^{\pi}\frac{(r+R\cos\Theta)}{\left[R^2+(r+\cos\Theta)^2\right]^{3/2}}\sin\Theta\, d\Theta$$

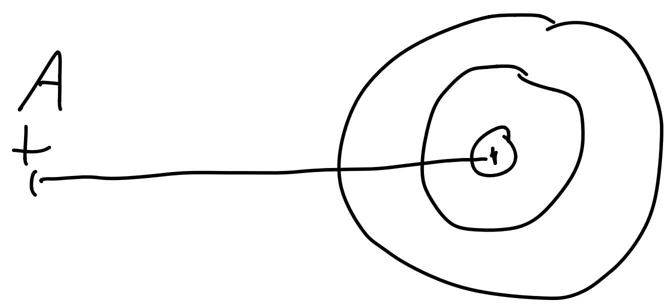
Complicated!

$$\vec{E} = \begin{cases} \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \hat{r}, & r > R \\ 0, & r < R \end{cases}$$

Field of a solid sphere







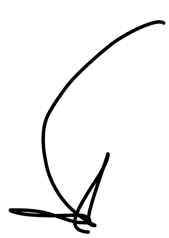
$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3$$

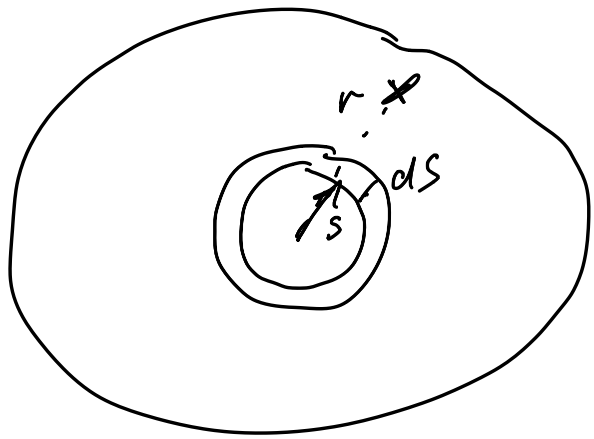
$$= \frac{k\Delta Q}{r^2}\hat{r} + \frac{k\Delta Q}{r^2}\hat{r} + \frac{k\Delta Q}{r^2}\hat{r}$$

$$\sum \Delta Q = Q$$

$$\vec{E}_{outside} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}\hat{r}$$

inside



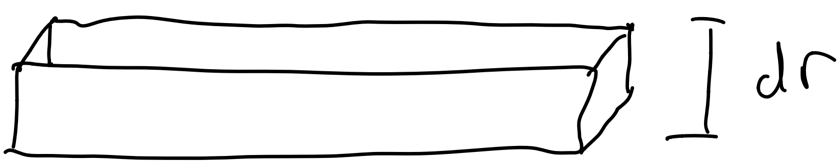


Q

$$\text{dens} = \frac{Q}{V} = \frac{Q}{4/3\pi R^3}$$

V_{shell}

$$A = 4\pi s^2$$



$$V = A \cdot h$$

$$V = 4\pi s^2 \, ds$$

$$dQ = Q\frac{4\pi s^2\, ds}{4/3\pi R^3} = \frac{3Q s^2 ds}{R^3}$$

$$dE = \frac{1}{4\pi\epsilon_0} \frac{dq}{r^2}$$

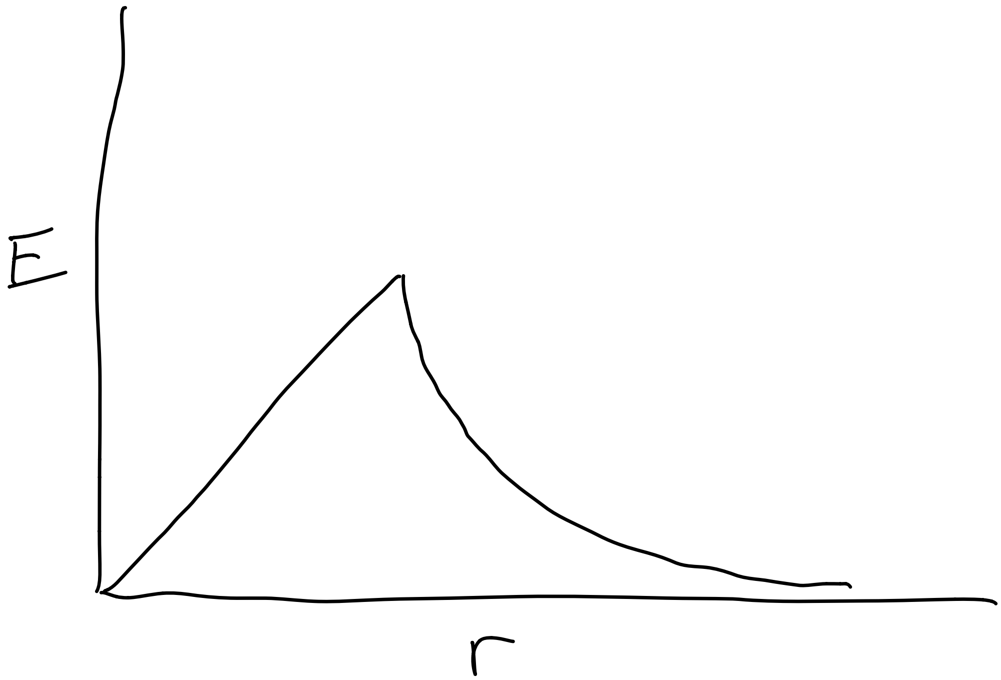
$$= \frac{1}{4\pi\epsilon_0} \frac{3Q s^2 ds}{r^2 R^3}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{3Q}{R^3 r^2} \int_0^r s^2 ds$$

$$= \frac{1}{4\pi\epsilon_0} \frac{3Q}{R^3 r^2} \frac{1}{3} r^3$$

$$E = \frac{Q}{4\pi\epsilon_0} \frac{r}{R^3}$$

$$E_{\substack{\text{solid} \\ \text{sphere}}} = \begin{cases} \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \ ; & r > R \\ \frac{1}{4\pi\epsilon_0} \frac{Qr}{R^3} \ ; & r < R \end{cases}$$


E
r