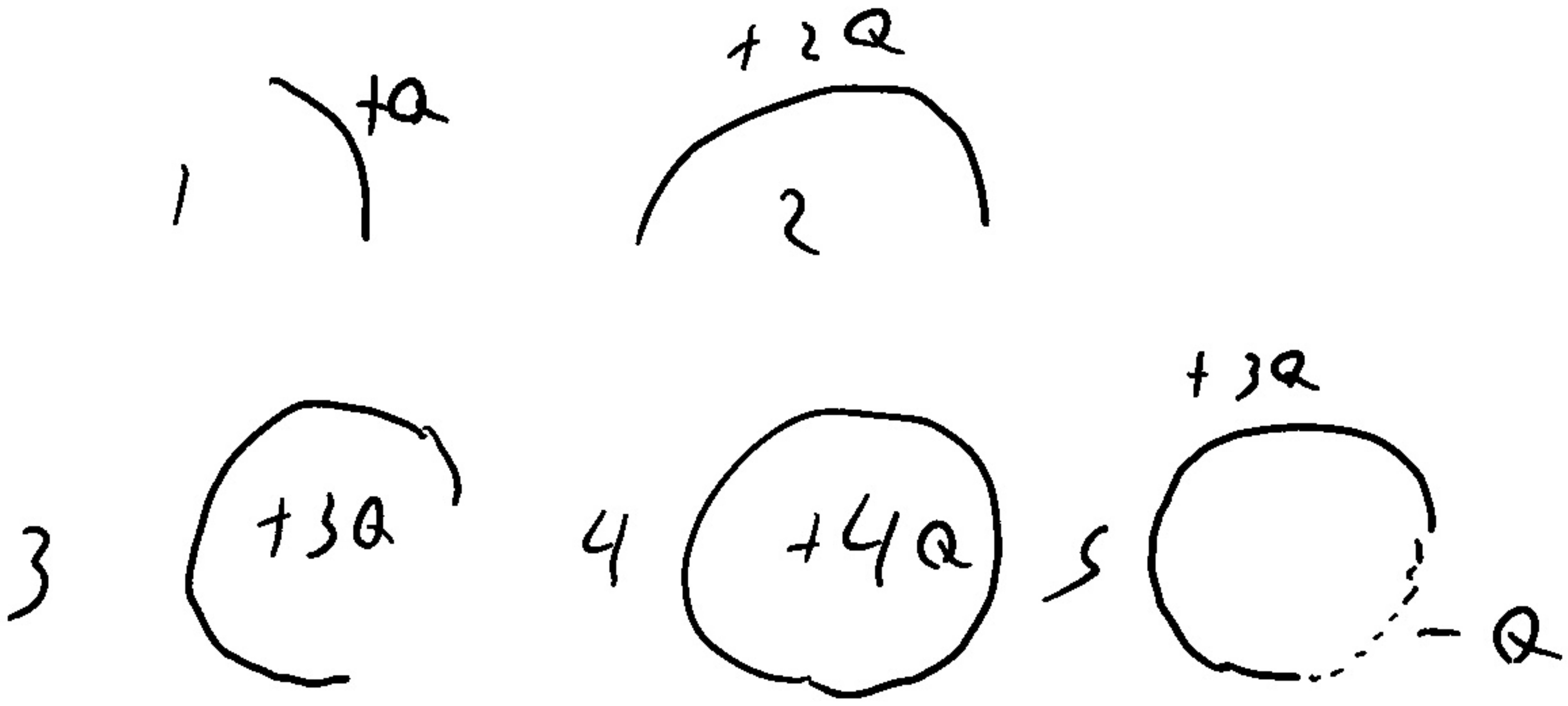
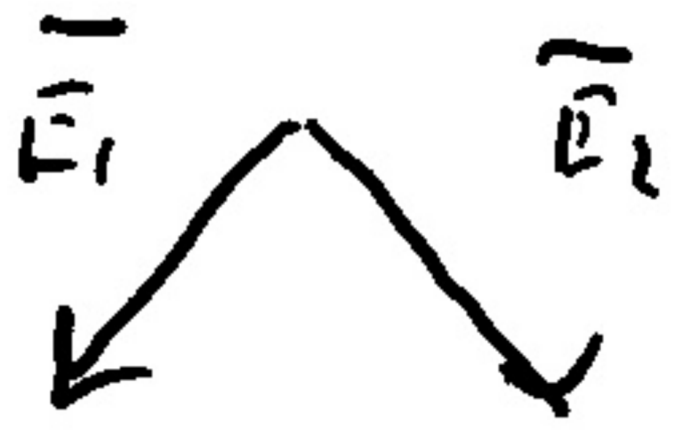
C4:



Field of 1

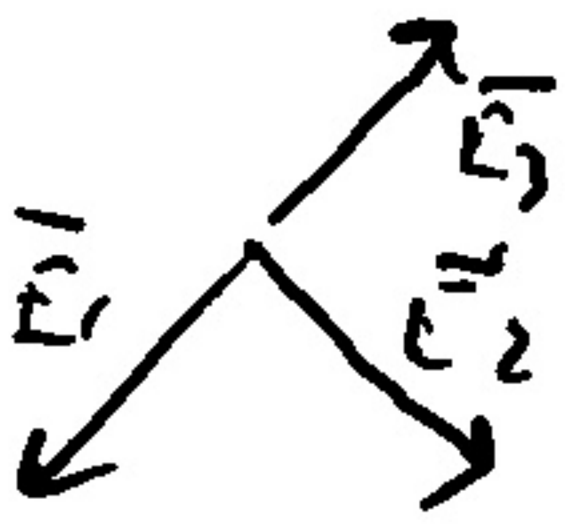
$|\vec{E}_{tot}| = |\vec{E}_1|$ ③

Field of 2



$|\vec{E}_{tot}| = \sqrt{2}\,|\vec{E}_1|$ ②

Field of 3

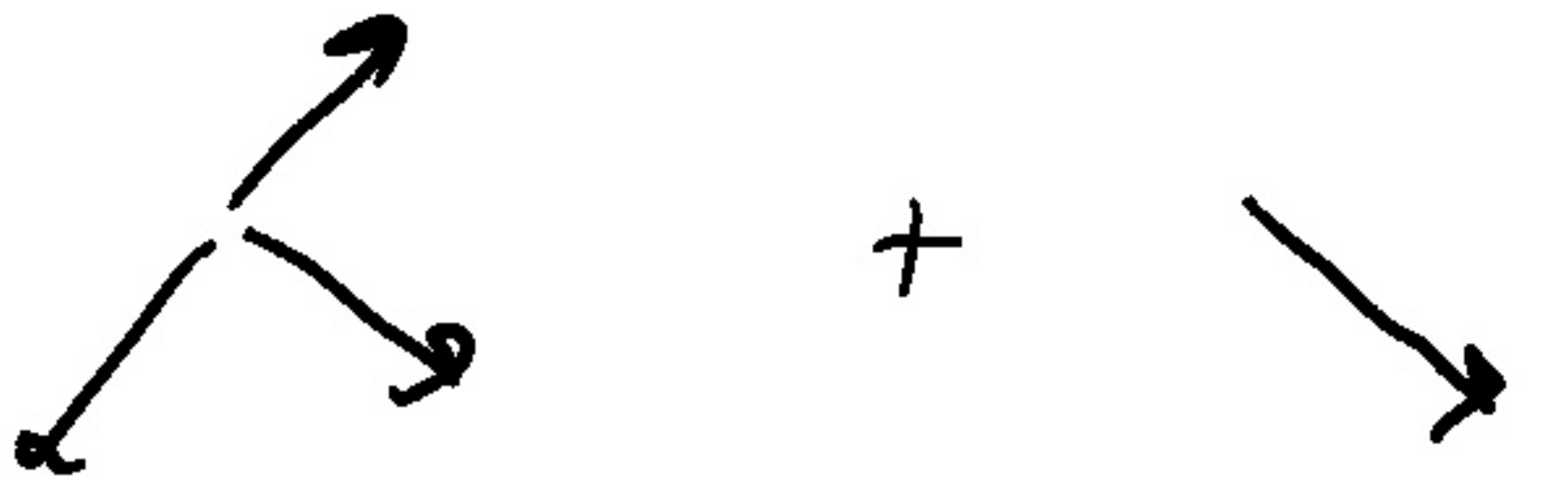


$|\vec{E}_{tot}| = |\vec{E}_2| = |\vec{E}_1|$ ③

Field of 4

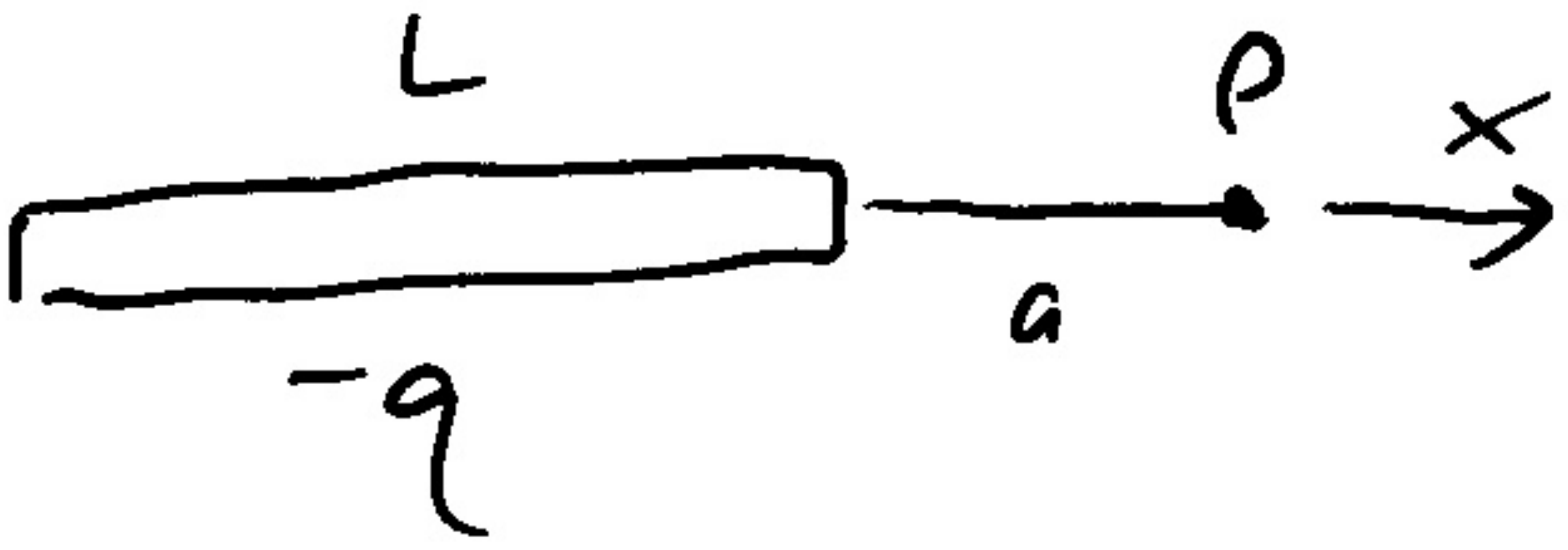
$\vec{E}_{tot} = 0$ ⑤

Field of S ①



$$\vec{E}_{tot} = 2|\vec{E}_2|$$
$$= 2|\vec{E}_1|$$

MS:



a. $\lambda = -q/L$

b. $$dE = \frac{dq}{4\pi\epsilon_0 r^2} = \frac{\lambda\,dx}{4\pi\epsilon_0 x^2}$$

$$E = \int_{-L-a}^{-a} dE = \int_{-L-a}^{-a} \frac{\lambda\,dx}{4\pi\epsilon_0 x^2}$$

$$= \frac{-\lambda}{4\pi\epsilon_0 x}\Big|_{-L-a}^{-a}$$

$$= \frac{-\lambda}{4\pi\epsilon_0 (-a)} - \frac{-\lambda}{4\pi\epsilon_0 (-L-a)}$$

$$= \frac{\lambda}{4\pi\epsilon_0 a} - \frac{\lambda}{4\pi\epsilon_0 (L+a)}$$

$$= \frac{-q}{4\pi\epsilon_0 a L} - \frac{-q}{4\pi\epsilon_0 L (L+a)}$$

$$= \frac{q}{4\pi\epsilon_0 L}\left(\frac{1}{L+a} - \frac{1}{a}\right) < 0,$$ so to left ←

$$\frac{1}{L+a} = \frac{1}{a\left(1+L/a\right)}$$

$$= 1/a\left(1 - L/a + \left(L/a\right)^2 - - -\right.$$

$$\text{so} \quad \frac{1}{L+a} - \frac{1}{a} = -L/a^2 + L^2/a^3 - - -$$

$$\text{so} \quad E = \frac{q}{4\pi\varepsilon_0 L}\left(-L/a^2 + L^2/a^3 - - -\right)$$

$$= \frac{-q}{4\pi\varepsilon_0 a^2} + \frac{qL}{4\pi\varepsilon_0 a^3} - - -$$

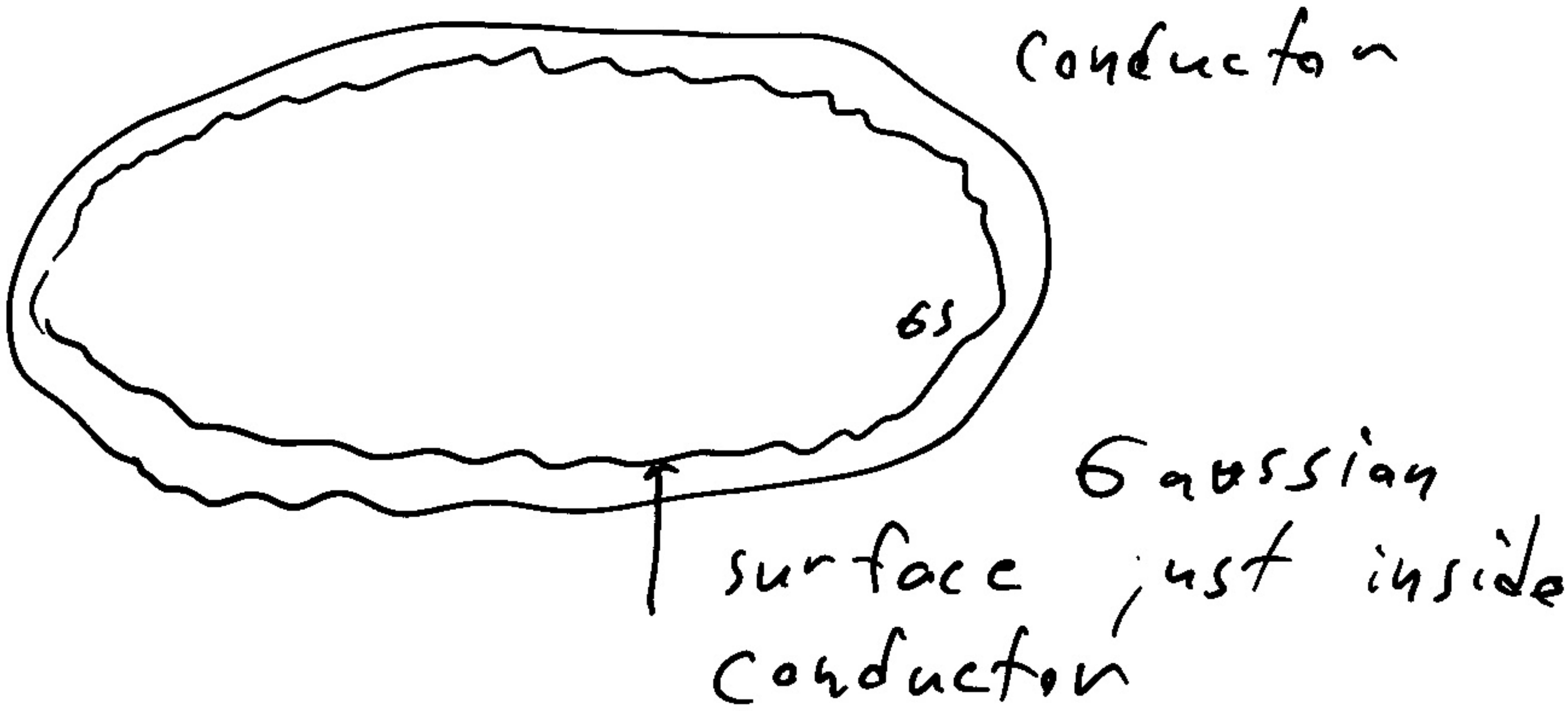
Field of pt. charge

Reduction due to spreading out charge

$$= -\frac{q}{4\pi\varepsilon_0 a^2}\left[1 - L/a - -\right]$$

Charge in Conductors

- No $\vec{E}$ in conductor because free charge flows to cancel it.
- What about charge?

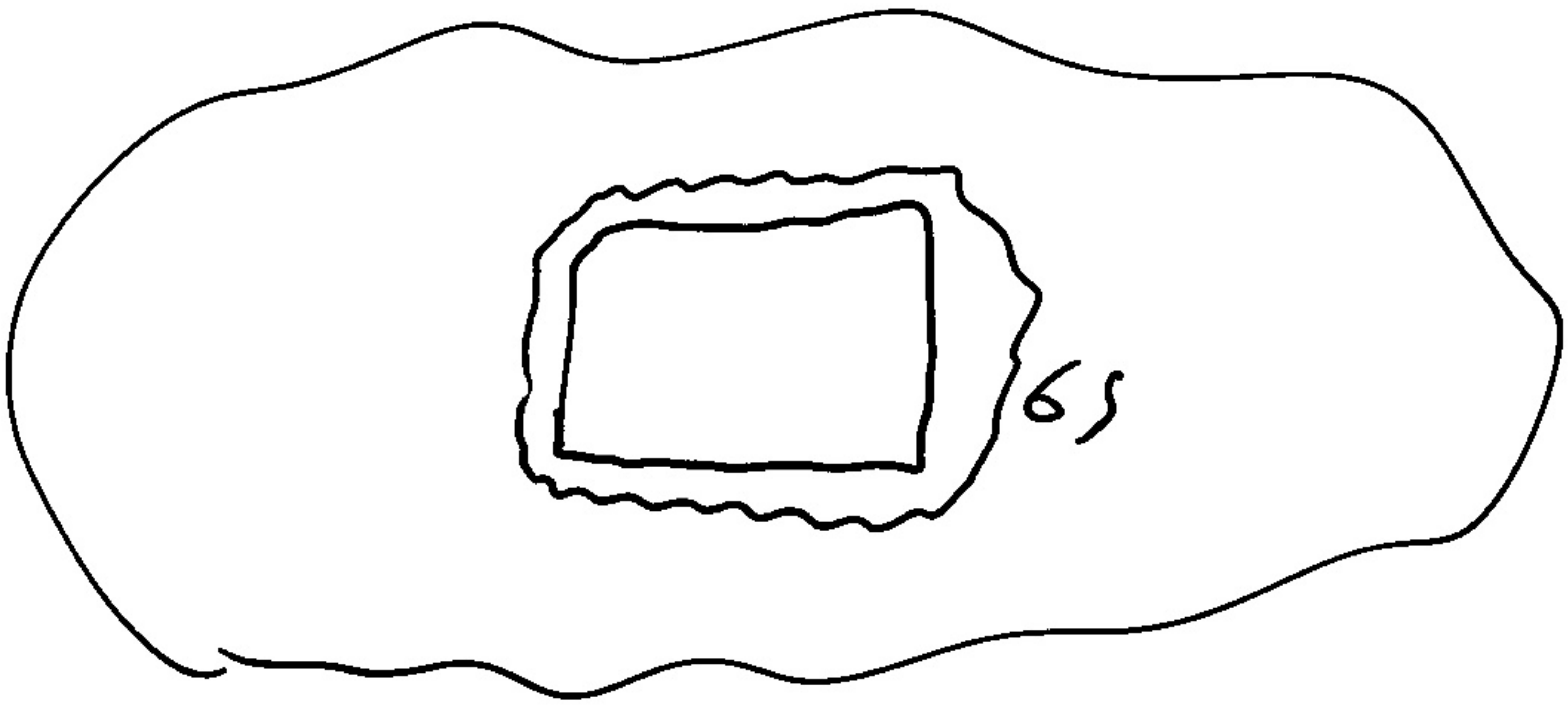


$\oint \vec{E} \cdot d\vec{A} = 0$ since $\vec{E} = 0$ all over surface

- This implies $q_{enc} = 0$
- True for any surface inside
- No free charge in conductor!

- Any charge on conductor must be on surface

Scoop out a hole



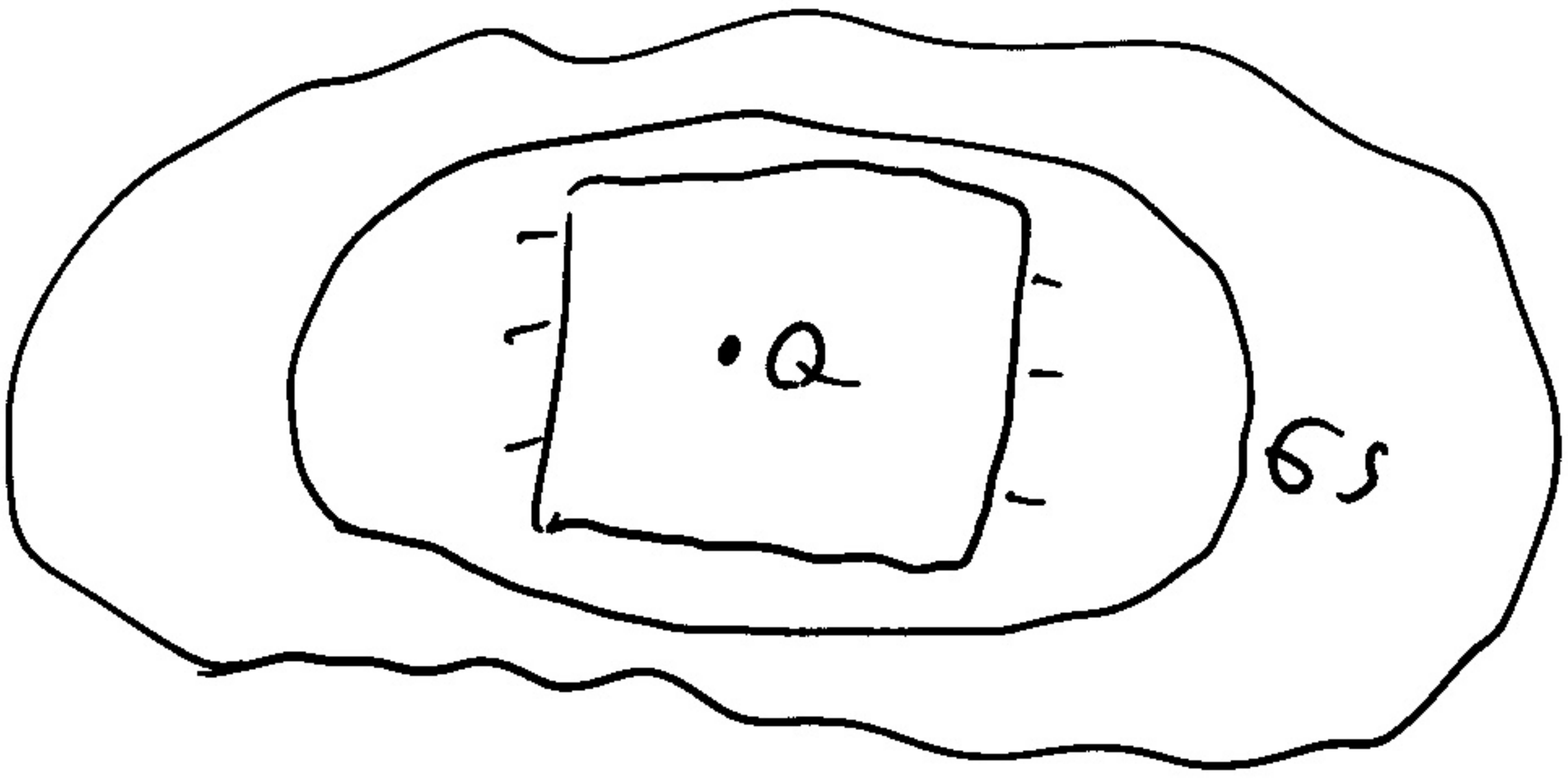
- Again $\vec{E} = 0 \Rightarrow \oint \vec{E} \cdot d\vec{A} = 0$
  $\Rightarrow q_{enc} = 0$

- Since no q_{enc} throughout hole, $\vec{E} = 0$

- But wait!

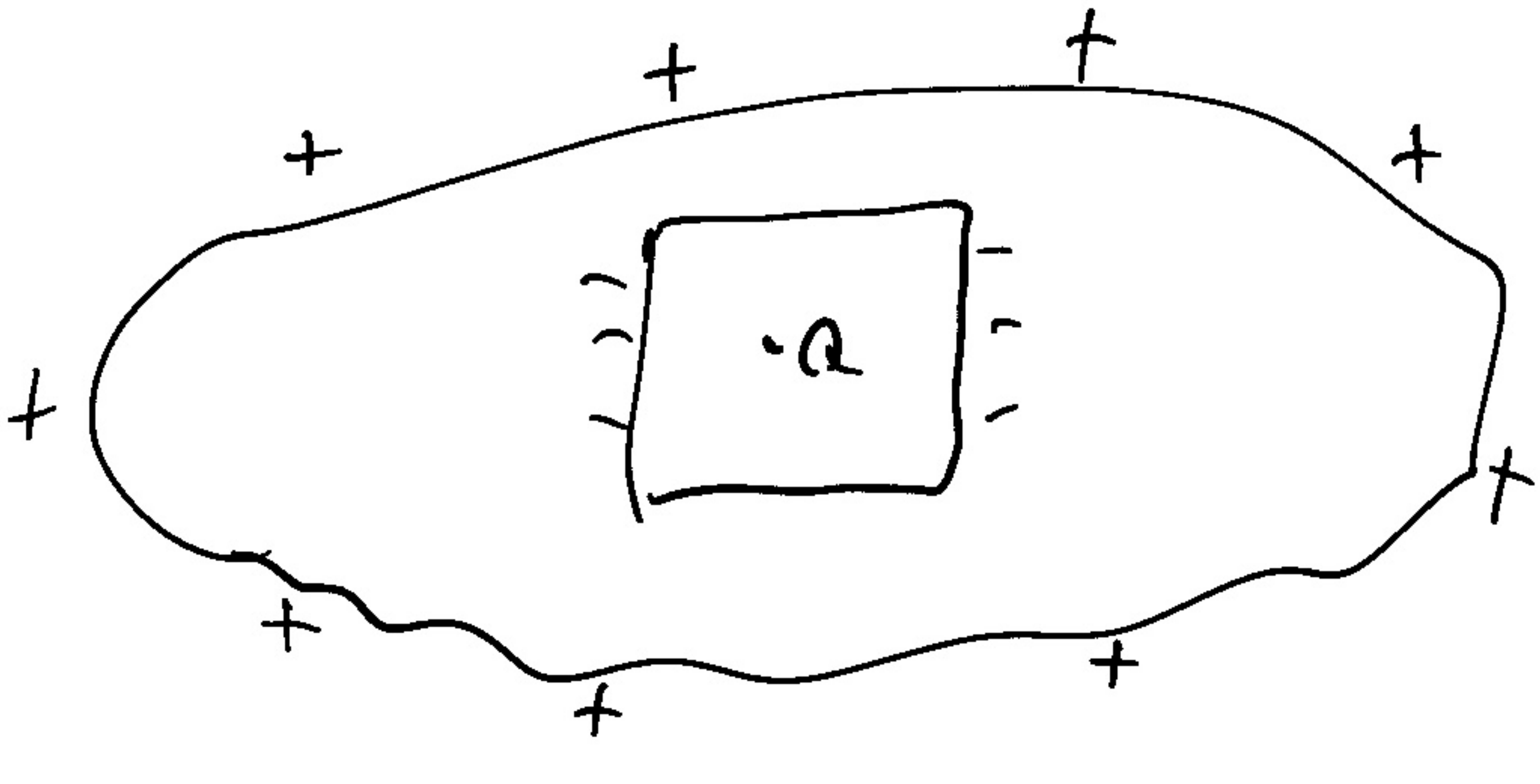
- What if we put $+Q$ in hole?

$\vec{E} = 0$ in conductor, so $Q_{enc} = 0$ - only way to do this is the following

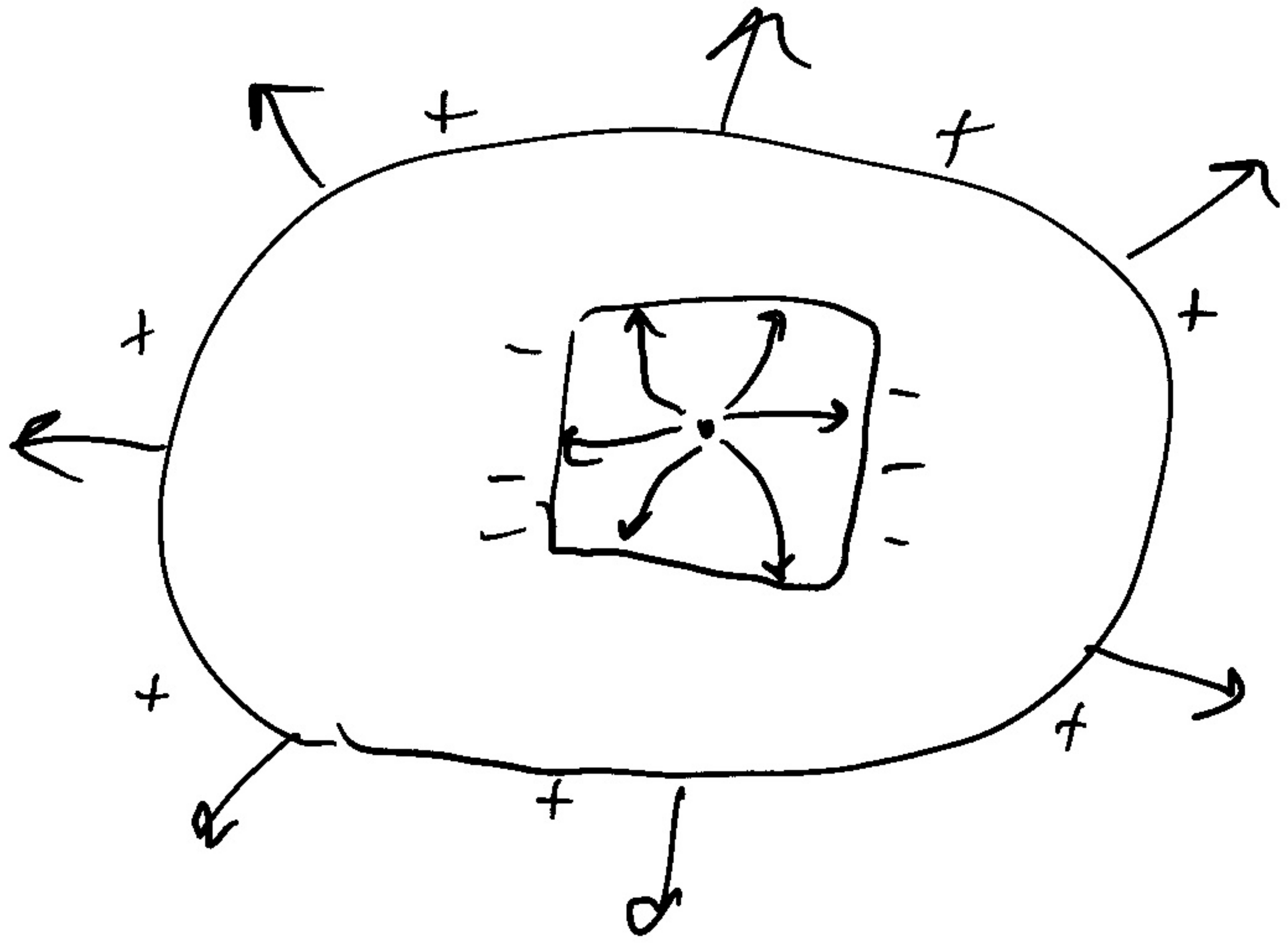


- Must have $q = -Q$ on inner edge of hole to satisfy Gauss's Law

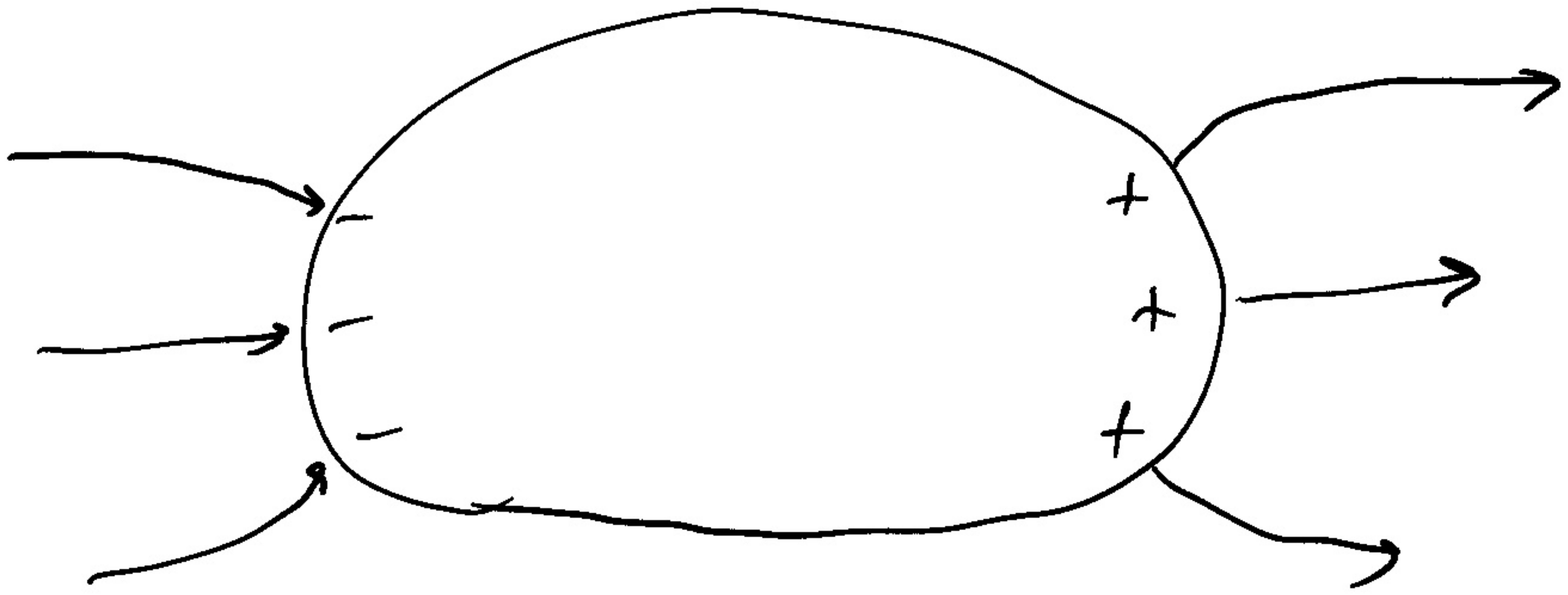
- Assuming we started w/ $q = 0$ on conductor, this leaves $q = Q$ on outside



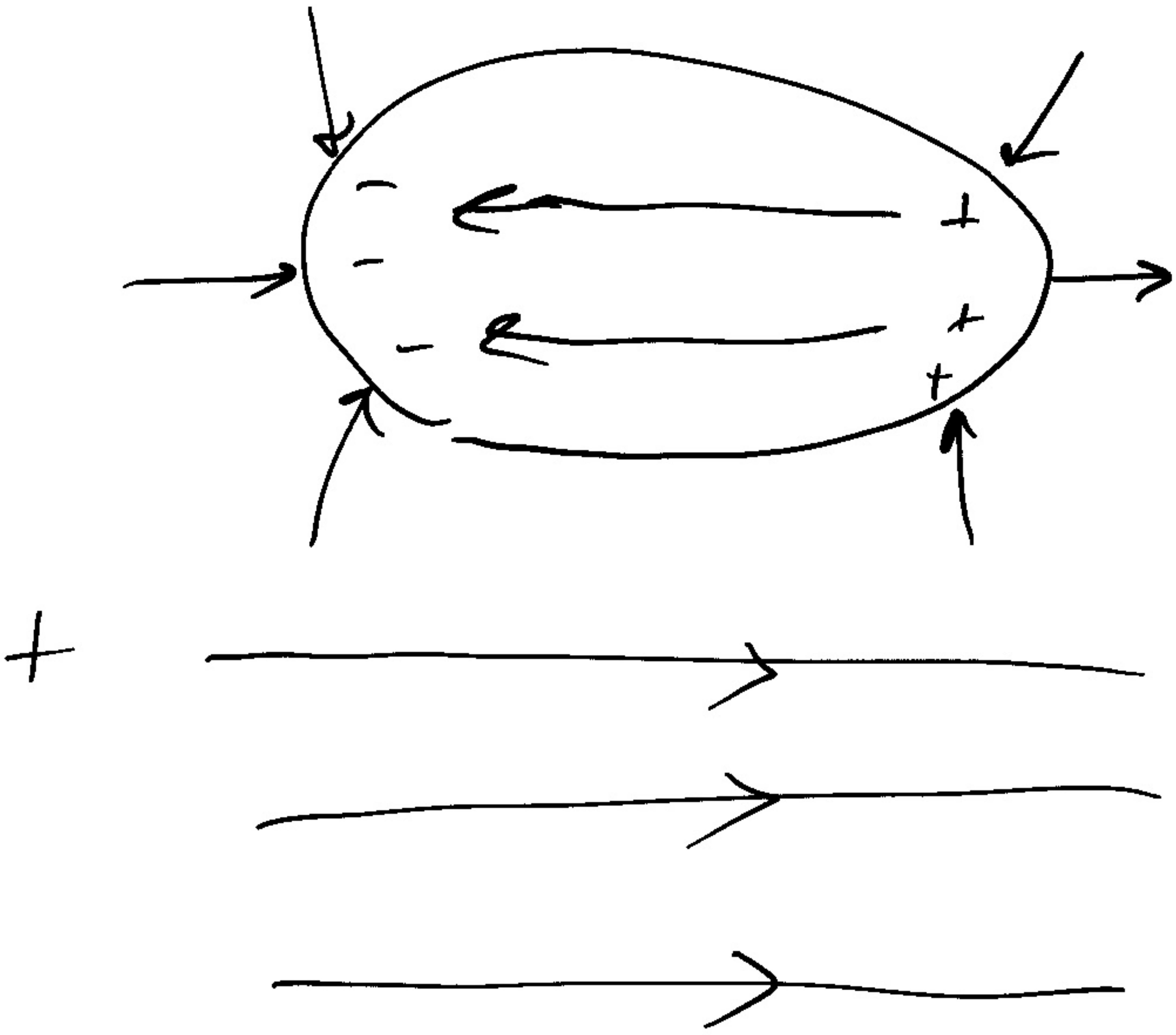
Field Lines



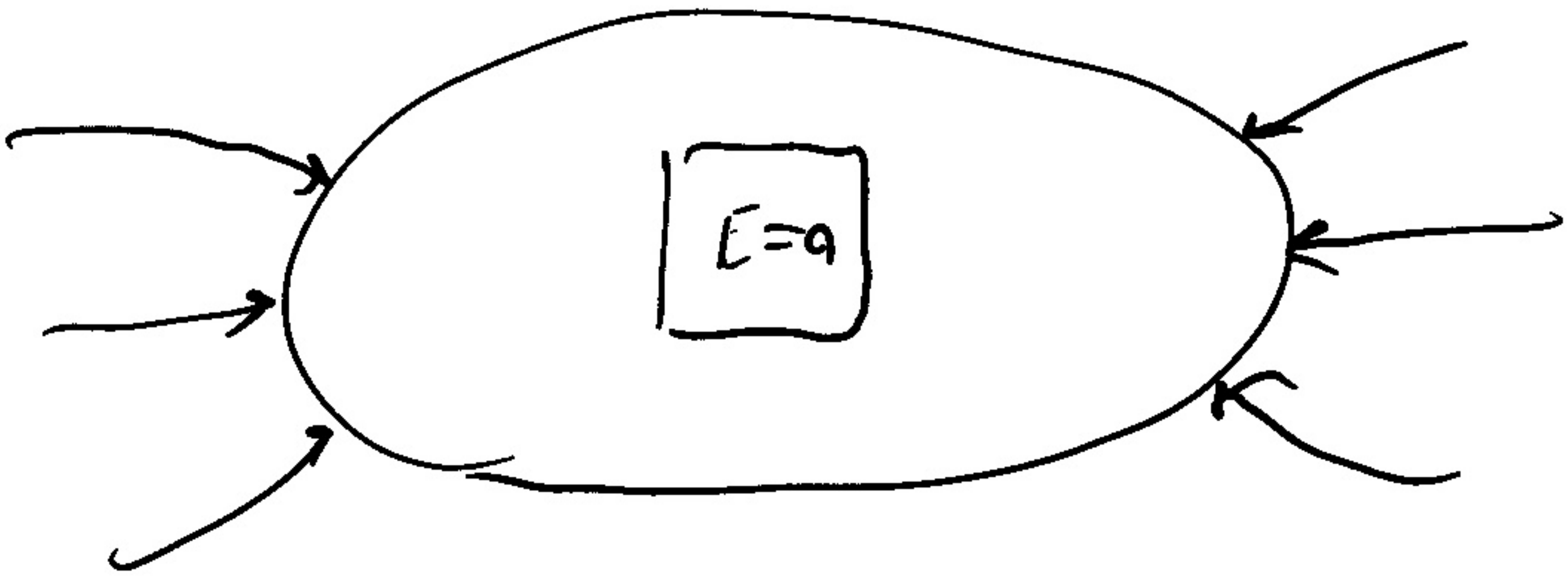
What if we impose an electric field?



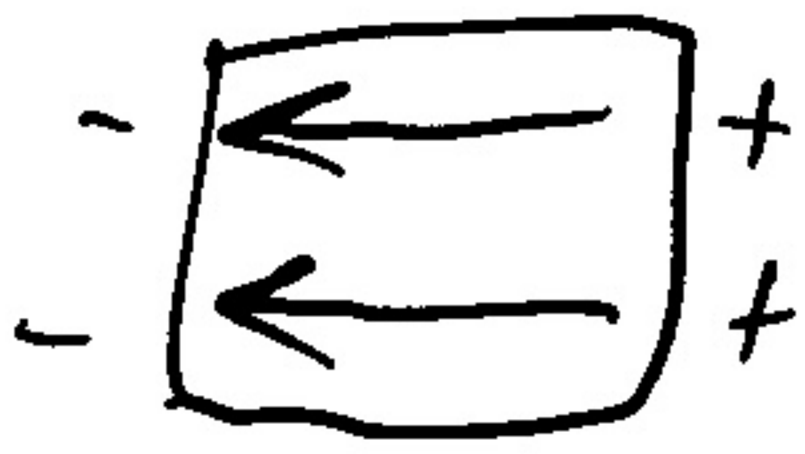
Charge moves to short out electric field



- Same is true if there is a hole



why not?



- charge would just flow to neutralize

Conclusion:

- No charge in conductor
- No charge in hole in conductor unless we put it there
  - If we put it there, equal and opposite charge will flow to balance it