

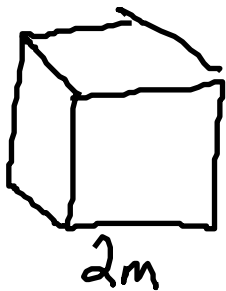
Continuous Charge Distributions

In 3D, charge density

~~Ⓟ~~ $\rho = \frac{Q}{V}$

ρ rho $\leftarrow$ total charge $\leftarrow$ volume

e.g.



$\rho = 50 \mu\text{C}/\text{m}^3$

"uniform" $\leftarrow$ same everywhere

$$Q_{\text{cube}} = \rho V$$

$$= \left(50 \frac{\mu\text{C}}{\text{m}^3} \right) (2\text{m})^3$$

$$= \left(50 \frac{\mu\text{C}}{\cancel{\text{m}^3}} \right) (8 \cancel{\text{m}^3}) = \boxed{400 \mu\text{C}}$$

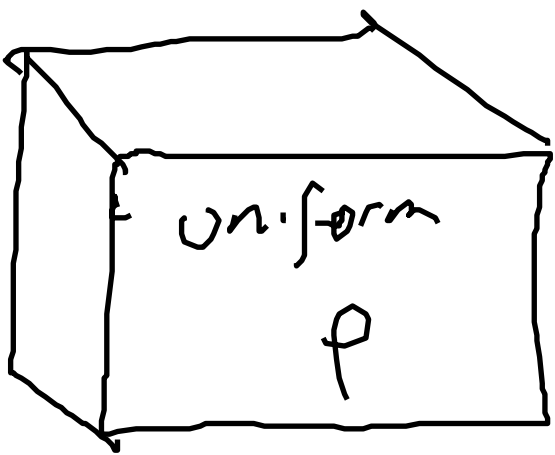
WRONG

not Q!

$$\frac{50 \frac{\mu\text{C}}{\text{m}^3}}{8 \text{m}^3}$$

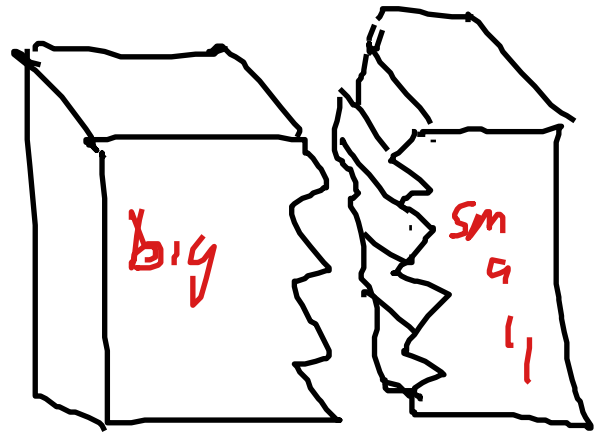
$$= 6.25$$

$$\frac{\mu\text{C}}{\text{m}^6}$$



A

has more Q
and more V



B

C

All have the
same density

Density is a local property;
doesn't depend on overall size

(Like mass density)

Surface charge density

$$\sigma = \frac{Q}{A} \rightarrow Q = \sigma A$$

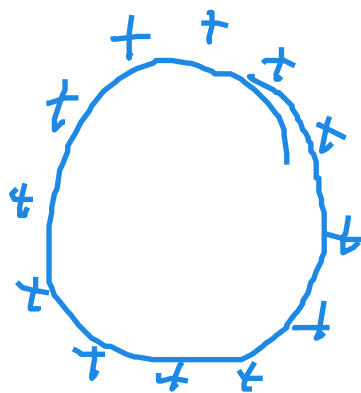
Sigma
↑
area
↑
C/m²

line charge density

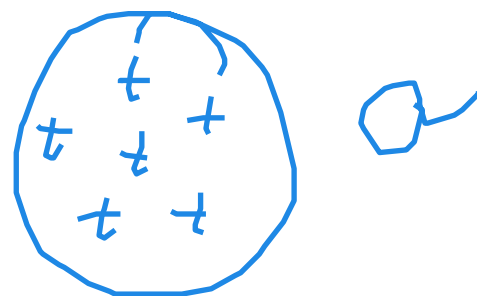
$$\lambda = \frac{Q}{L} \rightarrow Q = \lambda L$$

lambda
↑
length
↑
C/m

Ring of charge



Disk of charge



Spherical shell

- hollow chocolate

- charge on round eggshell

σ

Solid Sphere

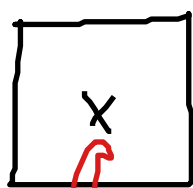
- includes the interior

ρ

Symmetry

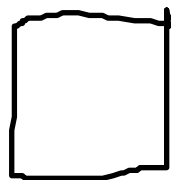
An object is Symmetric under an action if the object is unchanged after you do the action

- rotational symmetries

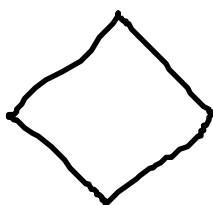
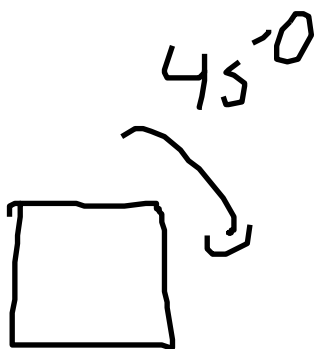


axis

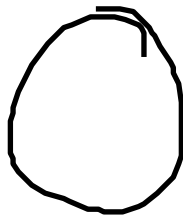
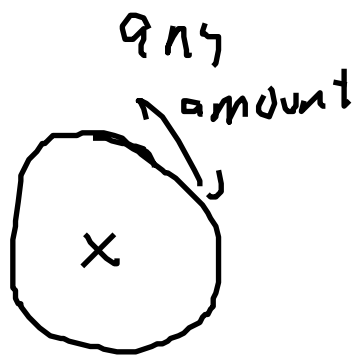
rotate
by
 90°
around
this
axis



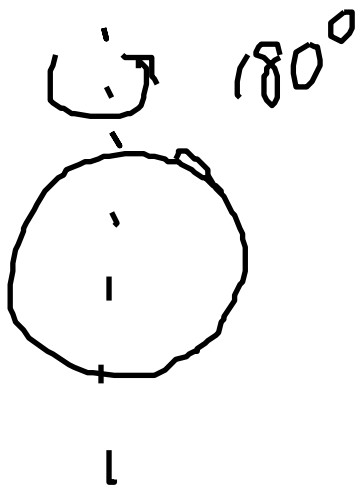
90°
rotational
symmetry
around its
center



not 45°
rotationally
symmetric

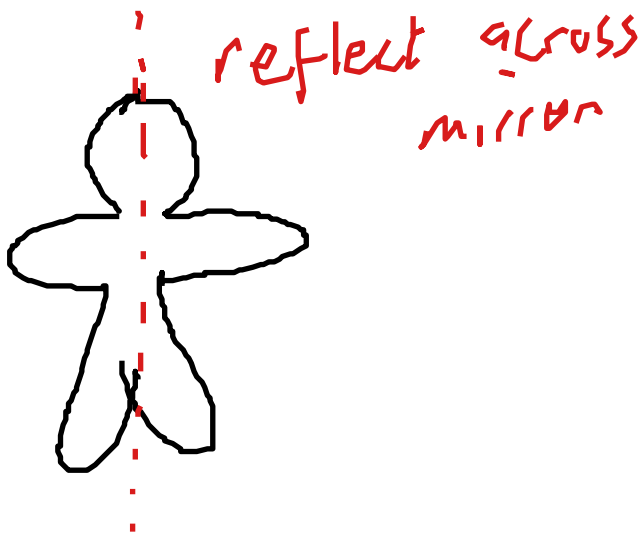


Continuous
rotational
symmetry
around center



180° rotational symmetry
around axis on its
plane through its center

- reflection symmetry
reflect across a "mirror" a plane

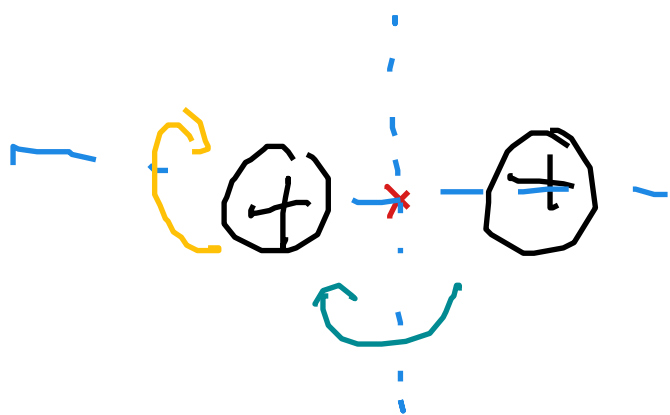


reflection
symmetry across
vertical mirror through
its center

But not across
horizontal mirror

7

If a set of source charges has a certain symmetry, the electric field they produce has the same symmetry, and vice versa



× Rotate 180° around axis $\perp$ to page through center

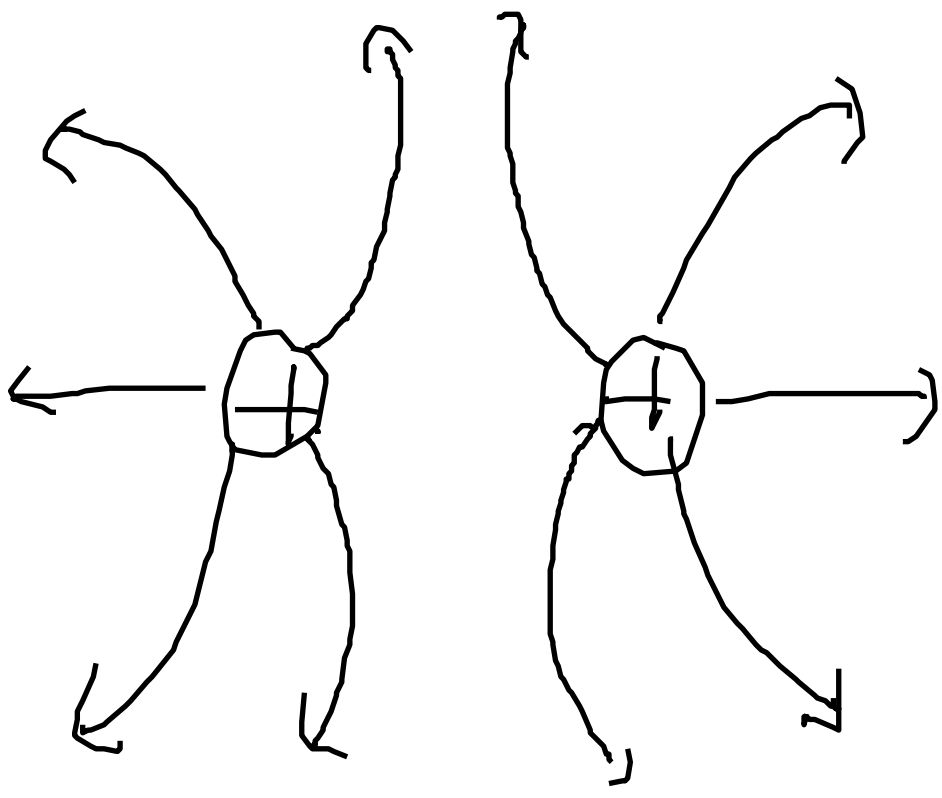
Reflect across a mirror vertical through center

Reflection across the page

Reflect across a horizontal mirror.

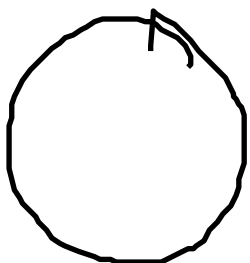
Rotate any amount around horizontal axis

Rotate 180° around vertical axis

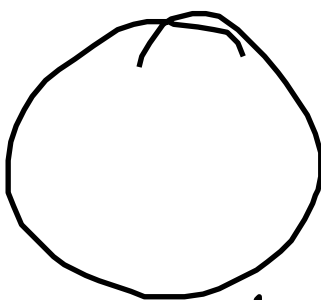


Spherical Symmetry

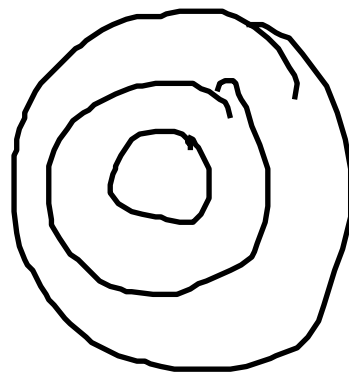
- continuous, rotational symmetry around ~~any~~ any axis through its center
- reflection across any mirror through its center



sphere



Spherical shell

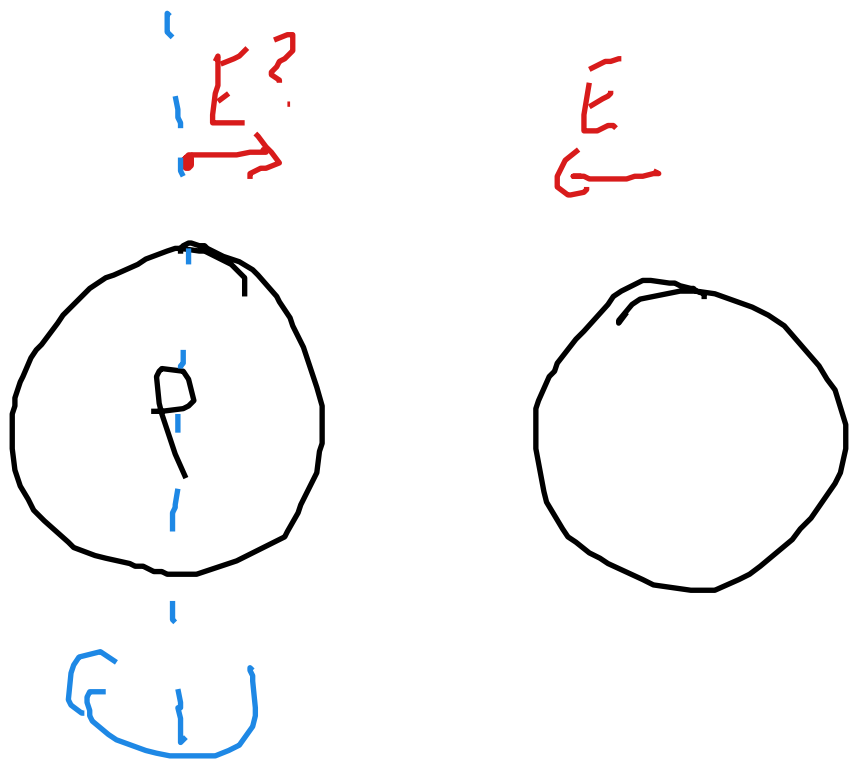


Concentric spherical shells



point

What Electric field has
spherical symmetry?



NO!

radial electric
fields have
this symmetry

