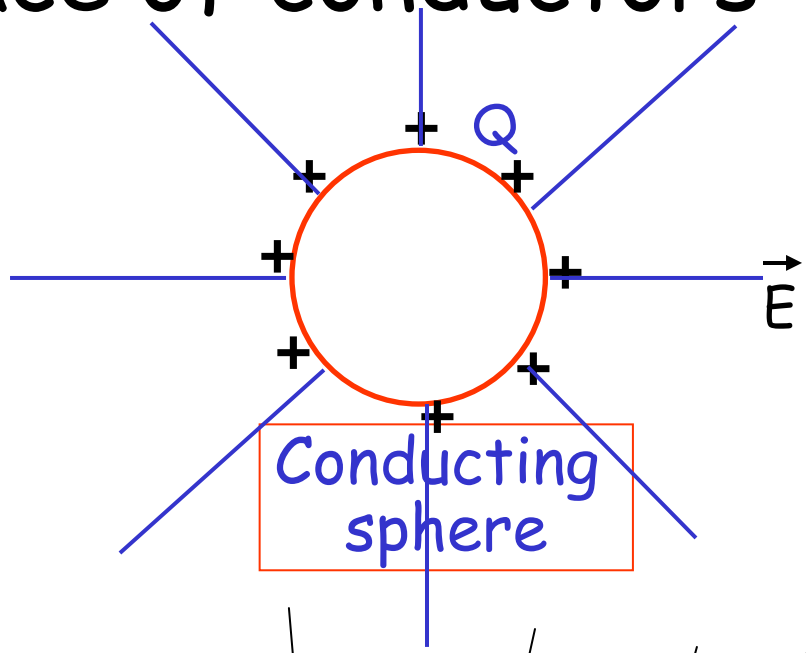
Fields at surface of conductors

Conducting sphere: charge distributes uniformly. $\vec{E}$ outside just like point charge Q.



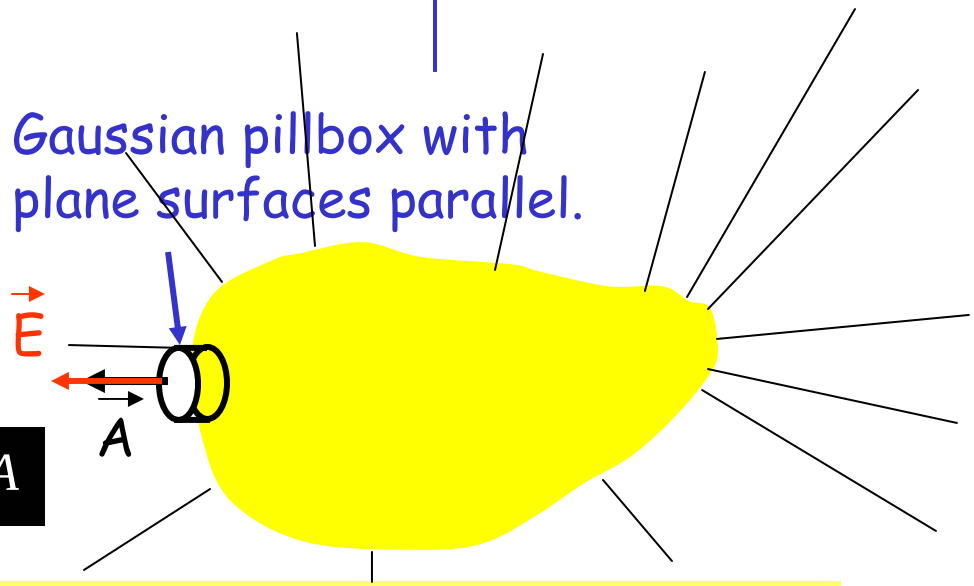
More general shape:

1. E is ⊥ to surface since there can be no component tangent.
2. Flux on cyl. surface is zero.
3. Flux on inside is zero.
4. Therefore

$$\oint \vec{E} \bullet d\vec{A} = \Phi_E = EA \cos\theta = EA$$

$$E = \frac{q}{\varepsilon_0 A} = \frac{\sigma}{\varepsilon_0}$$

Gaussian pillbox with plane surfaces parallel.



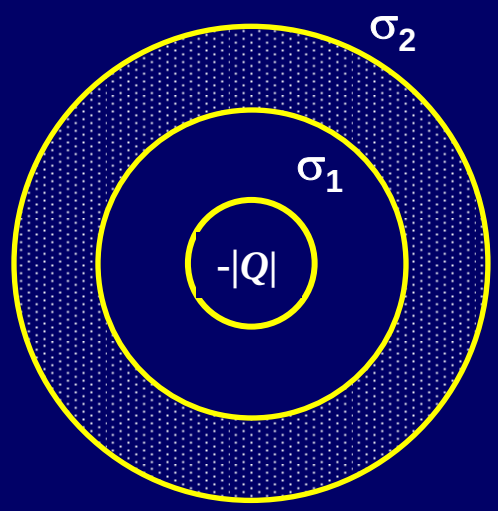
$\vec{E}$ at surface of conductor is normal and $E = \sigma/\varepsilon_0$.

Exercise 2a

Consider the following two topologies:

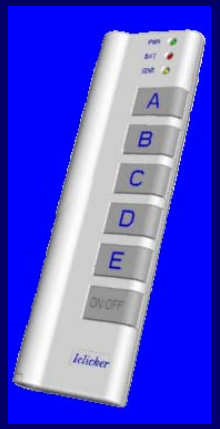
A) A solid non-conducting sphere carries a total charge Q = -3 μC distributed evenly throughout. It is surrounded by an *uncharged* conducting spherical shell.

B) Same as (A) but conducting shell removed



- **Compare the electric field at point X in cases A and B:**

(a) $E_A < E_B$ **(b)** $E_A = E_B$ **(c)** $E_A > E_B$



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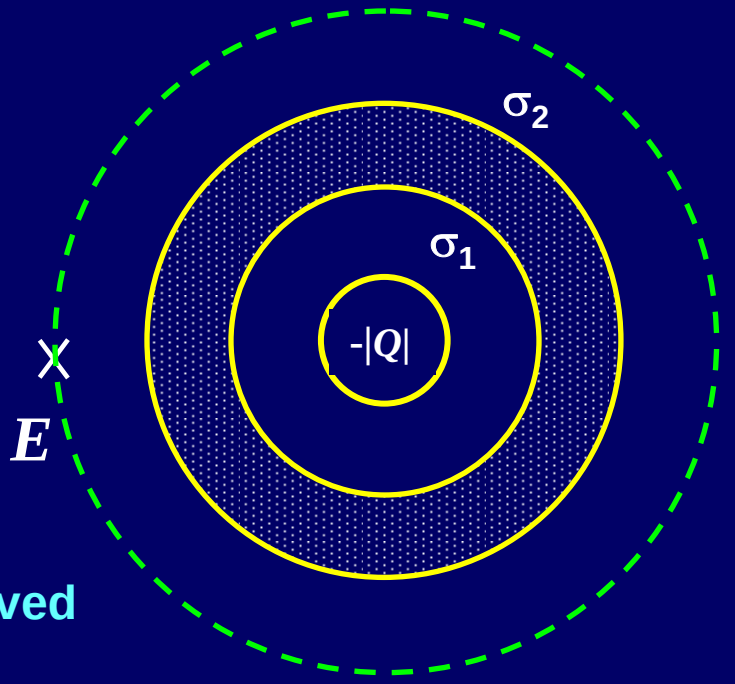


•Compare the electric field at point X in cases A and B:

(a) $E_A < E_B$ **(b) $E_A = E_B$** **(c) $E_A > E_B$**

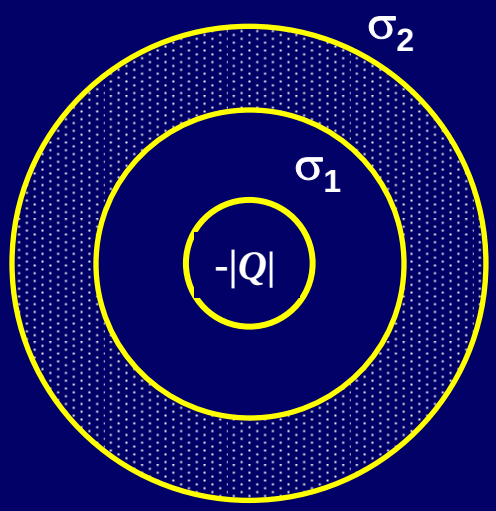
- **Select a sphere passing through the point X as the Gaussian surface.**
- **How much charge does it enclose?**
  - **Answer: -$|Q|$, whether or not the uncharged shell is present.**

(The field at point X is determined only by the objects with NET CHARGE.)

Exercise 2b

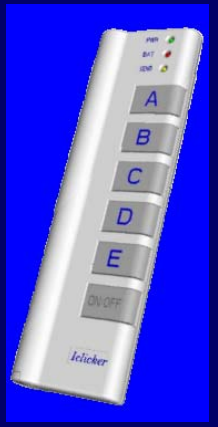
Consider again the topology:

A solid non-conducting sphere carries a total charge Q = -3 μC distributed evenly throughout. It is surrounded by an *uncharged* conducting spherical shell.



- **What is the surface charge density σ_1 on the inner surface of the conducting shell in case A?**

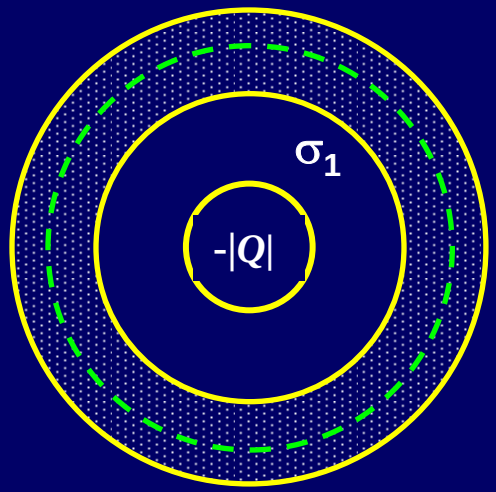
(a) $\sigma_1 < 0$ **(b)** $\sigma_1 = 0$ **(c)** $\sigma_1 > 0$



Exercise 2b

Consider the following topology:

A solid non-conducting sphere carries a total charge Q = -3 μC and is surrounded by an *uncharged* conducting spherical shell.



•What is the surface charge density σ_1 on the inner surface of the conducting shell in case A?

(a) $\sigma_1 < 0$ **(b)** $\sigma_1 = 0$ **(c)** $\sigma_1 > 0$

- **Inside the conductor, we know the field E = 0**
- **Select a Gaussian surface inside the conductor**
  - **Since E = 0 on this surface, the total enclosed charge must be 0**
  - **Therefore, σ_1 must be positive, to cancel the charge -$|Q|$**
- **By the way, to calculate the actual value: $\sigma_1 = -Q / (4 \pi r_1^2)$**