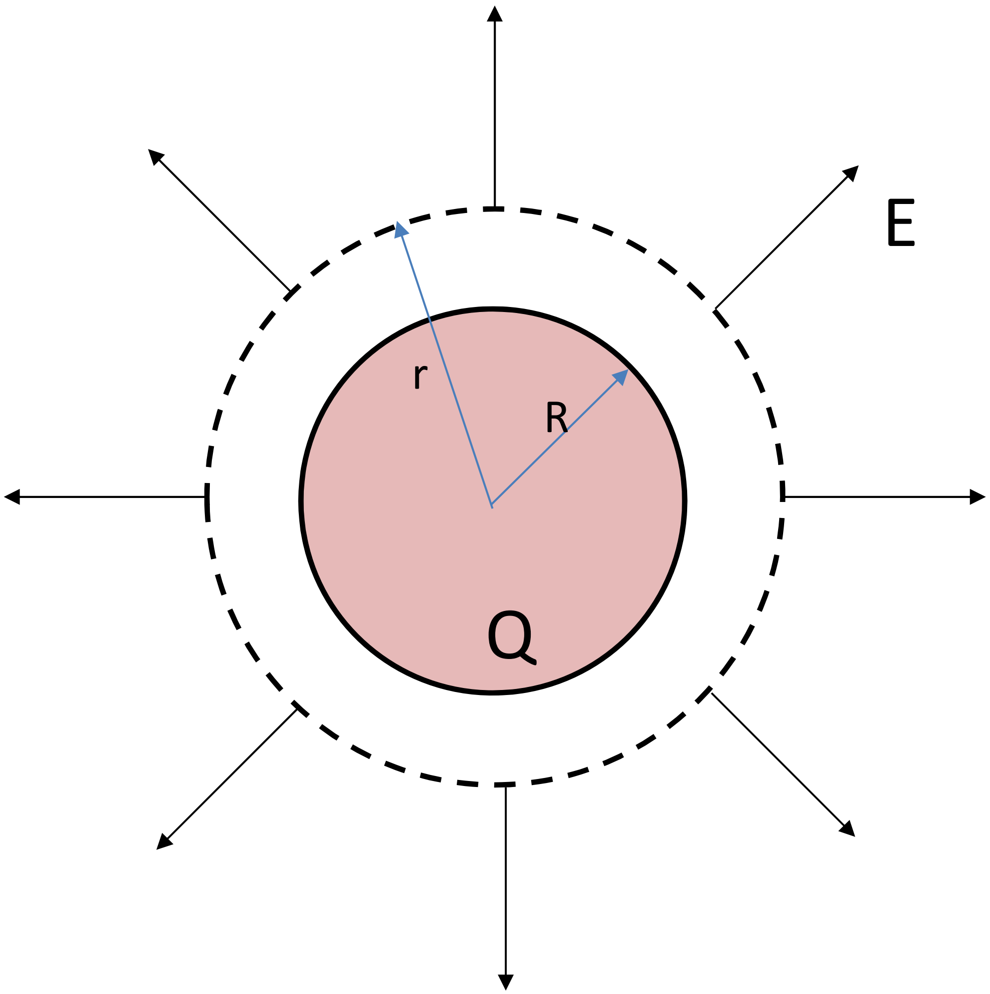
Class 8: Motion of Charged Particles in an Electric Field

Uniform spherical distribution



For r>R

$$\varepsilon_0 \Phi_E = Q \quad \Rightarrow \quad \varepsilon_0 \cdot E \cdot 4\pi r^2 = Q$$

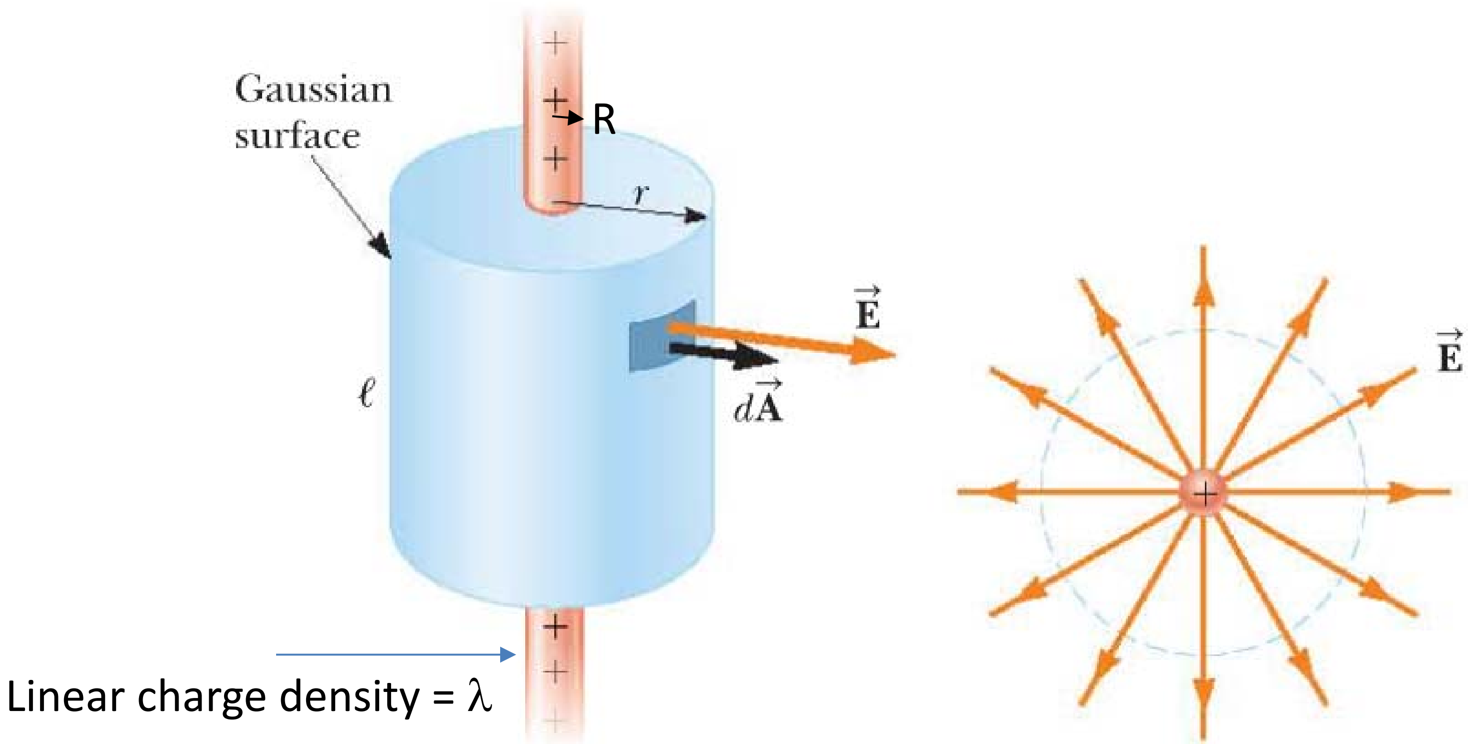
$$\Rightarrow \quad E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

Note that point charge belongs to this case.

For r<R

Depends on the actual charge distribution.

Uniform cylindrical (infinite long) distribution



For r>R $\varepsilon_0 \, \Phi_E = q_{in} \;\Rightarrow\; \varepsilon_0 \cdot E \cdot 2\pi \, r \, \ell = \lambda \, \ell$

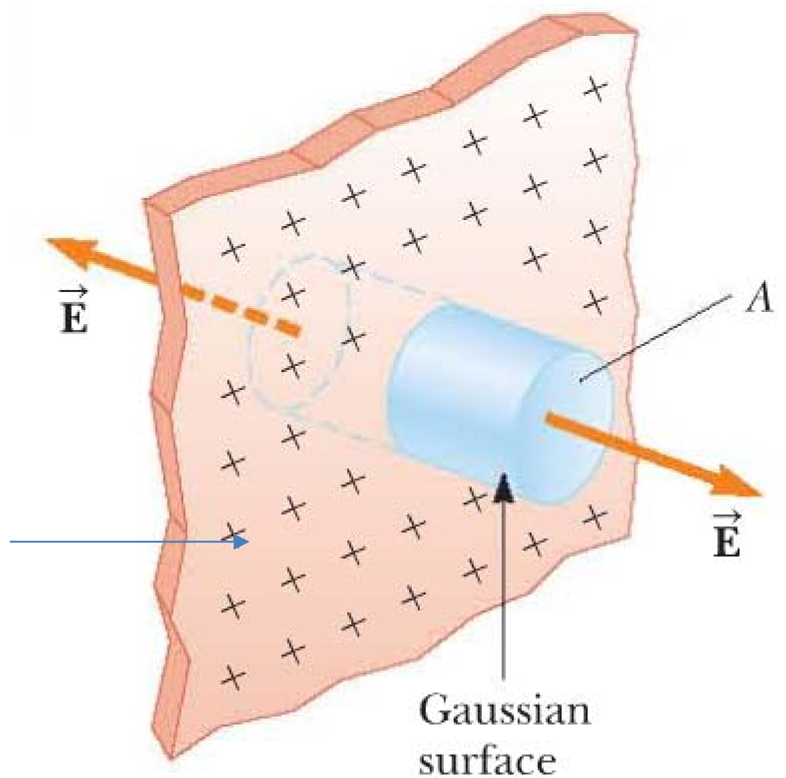
$$\Rightarrow\; E = \frac{\lambda}{2\pi\varepsilon_0 \, r}$$

Note that a line point charge belongs to this case.

For r<R Depends on the actual charge distribution.

Uniform distribution in an infinite plane

Surface charge density = σ



$$\varepsilon_0 \, \Phi_E = q_{in} \quad \Rightarrow \quad \varepsilon_0 \cdot 2 \cdot E \cdot A = \sigma A$$

$$\Rightarrow \quad E = \frac{\sigma}{2\,\varepsilon_0}$$

Note field is constant

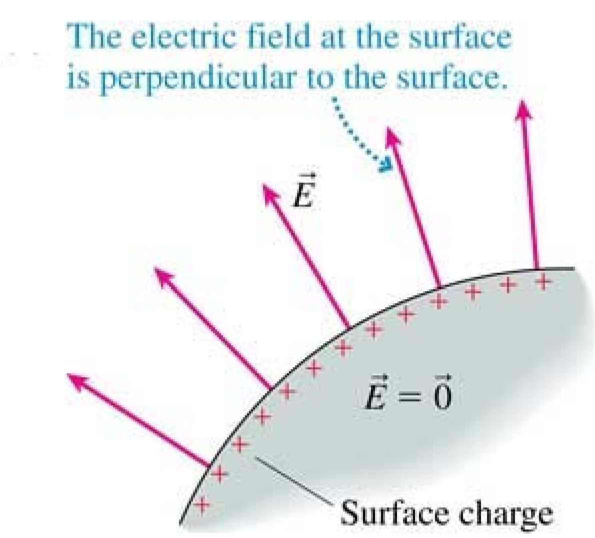
More on Conductors (as a Source of Electric Field)

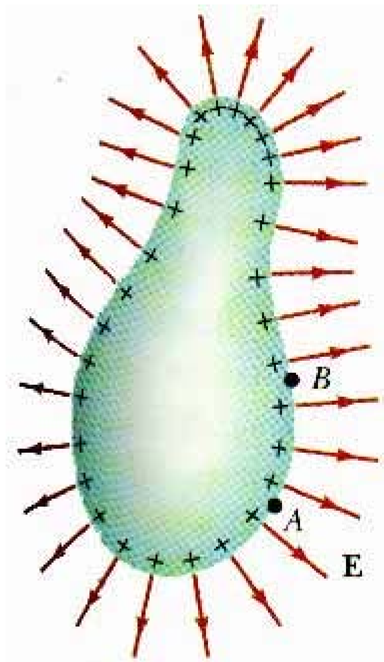
The following are true for any shape of a conductor, including the ones with cavities inside it (but assume there is no charge inside the cavities).

1.If the conductor has a net charge, all charges will stay only on the surfaces of the conductor.

2.There is no electric field inside the conductor.

3.The electric field outside the outer surface always perpendicular to the surface in the proximity of the conductor.





All on Conductors (as a Source of Electric Field)

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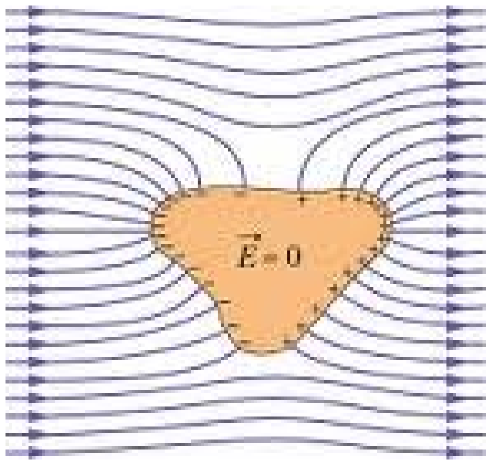
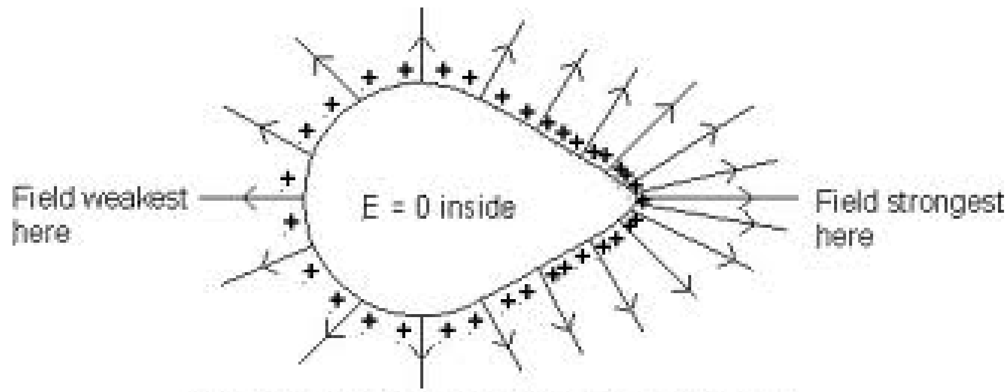
4. Electric field is stronger at the sharper part (smaller radius of curvature) of the outer surface.

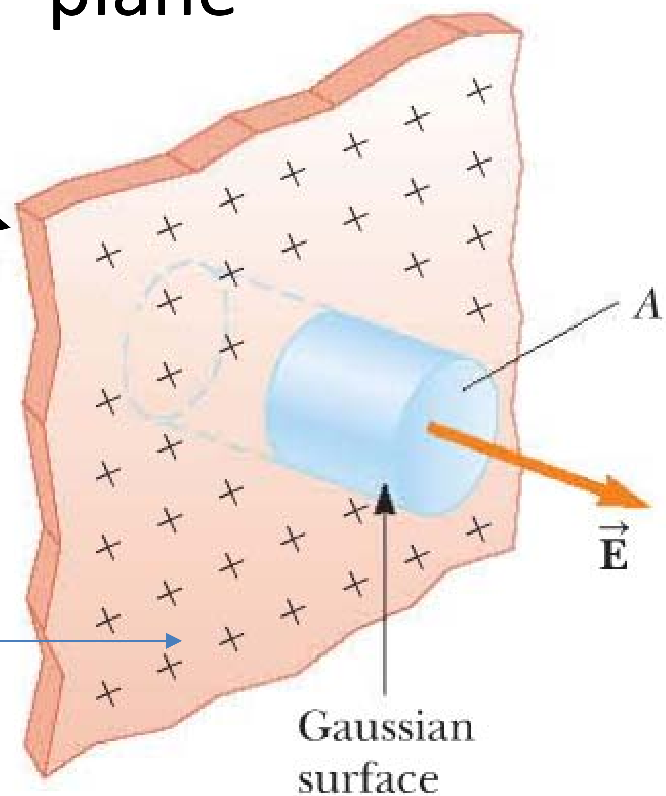




(d) Electric field & charge distribution around a pear-shaped conductor

Uniform distribution in an infinite conducting plane

If this is a conducting plate



Surface charge density = σ

$$\varepsilon_0 \Phi_E = q_{in} \Rightarrow \varepsilon_0 \cdot E \cdot A = \sigma A$$

$$\Rightarrow E = \frac{\sigma}{\varepsilon_0}$$

Note field is constant