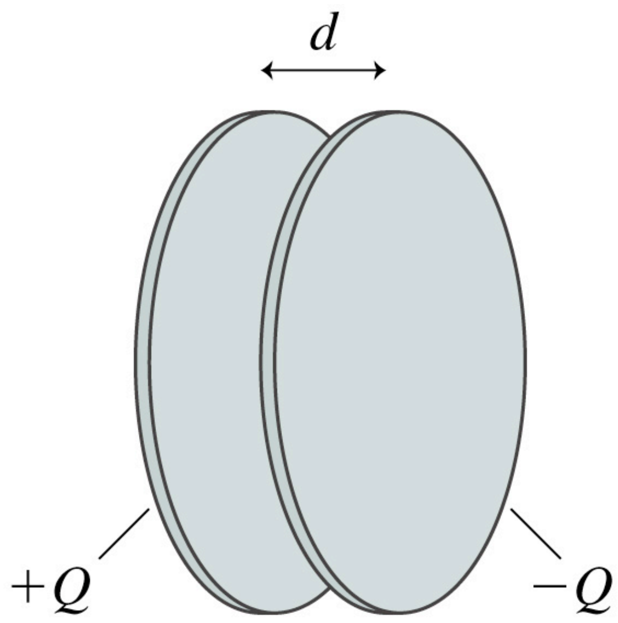
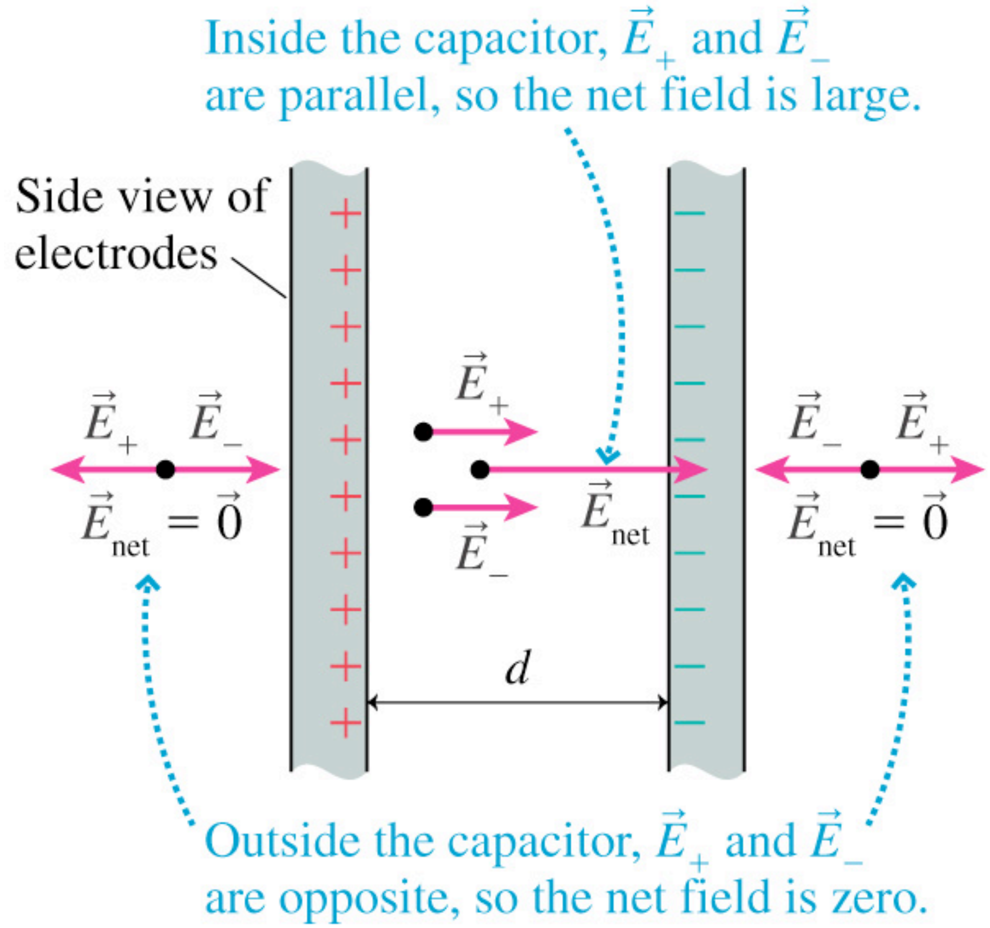
# Lecture19

- This week: parallel-plate capacitor
- motion of charged particle and dipole in $\bar{E}$
- chapter 28 (Gauss's Law)

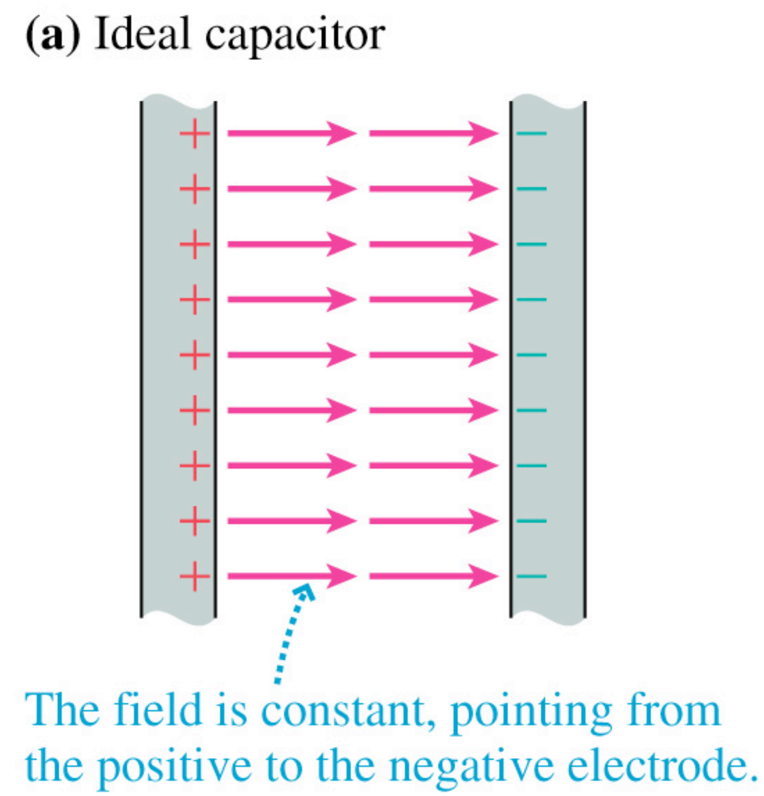
# Parallel-Plate Capacitor



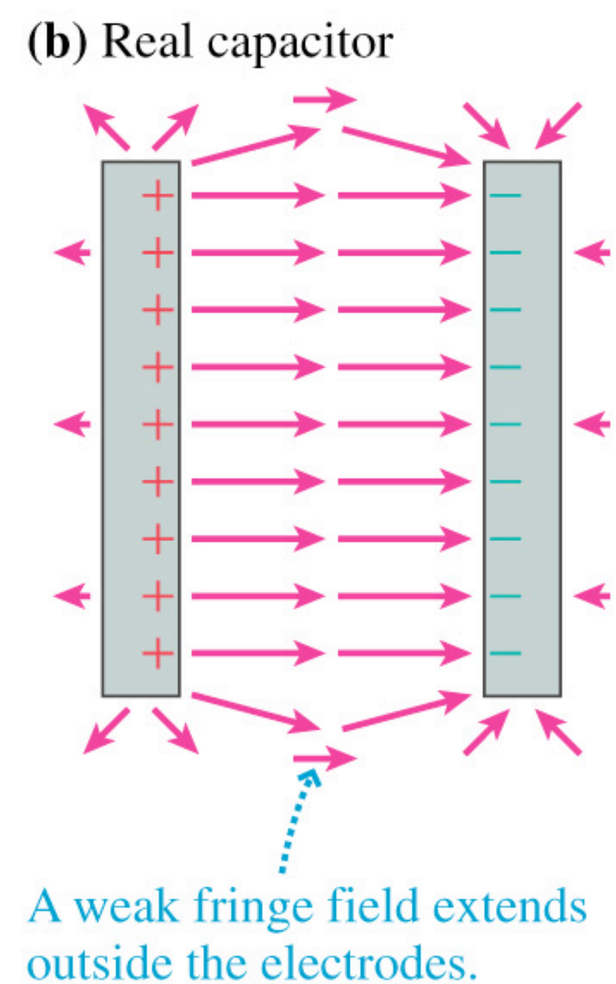







- 2 electrodes with charge $\pm Q$ separated by d << size of electrodes
- inside capacitor

$$\vec{E}_{capacitor} = \vec{E}_+ + \vec{E}_- = \left(\frac{\eta}{\epsilon_0}, \text{from positive to negative}_2\right)$$

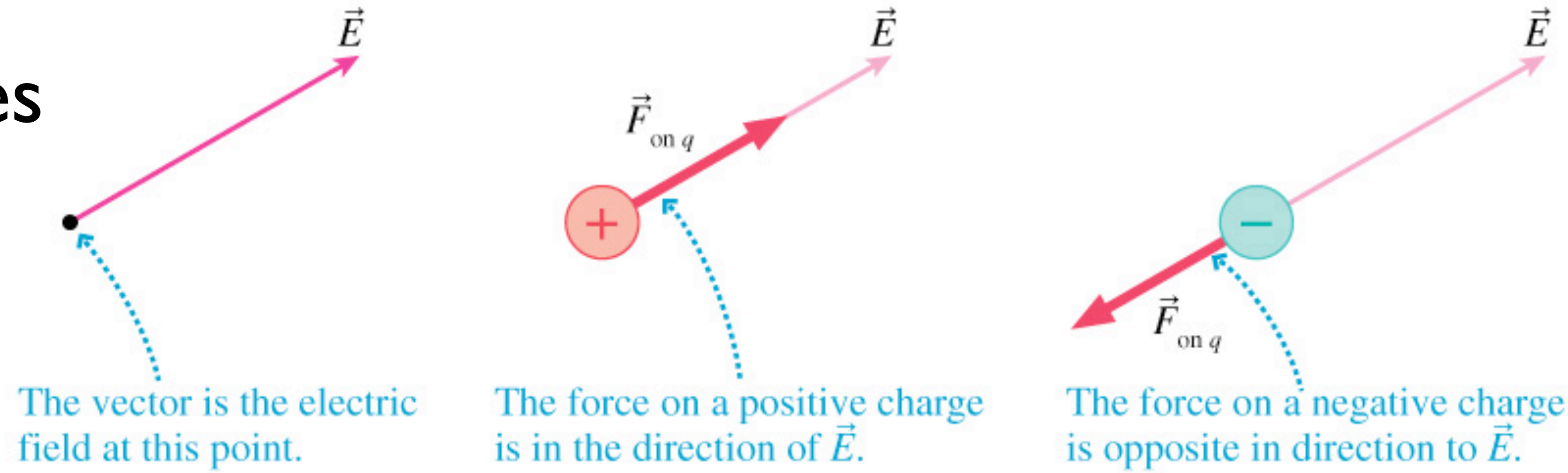
$$= \left(\frac{Q}{\epsilon_0 A}, \text{from positive to negative}\right)$$

- $\bar{E} = 0$ outside capacitor

# Motion of Charged Particle in Electric Field

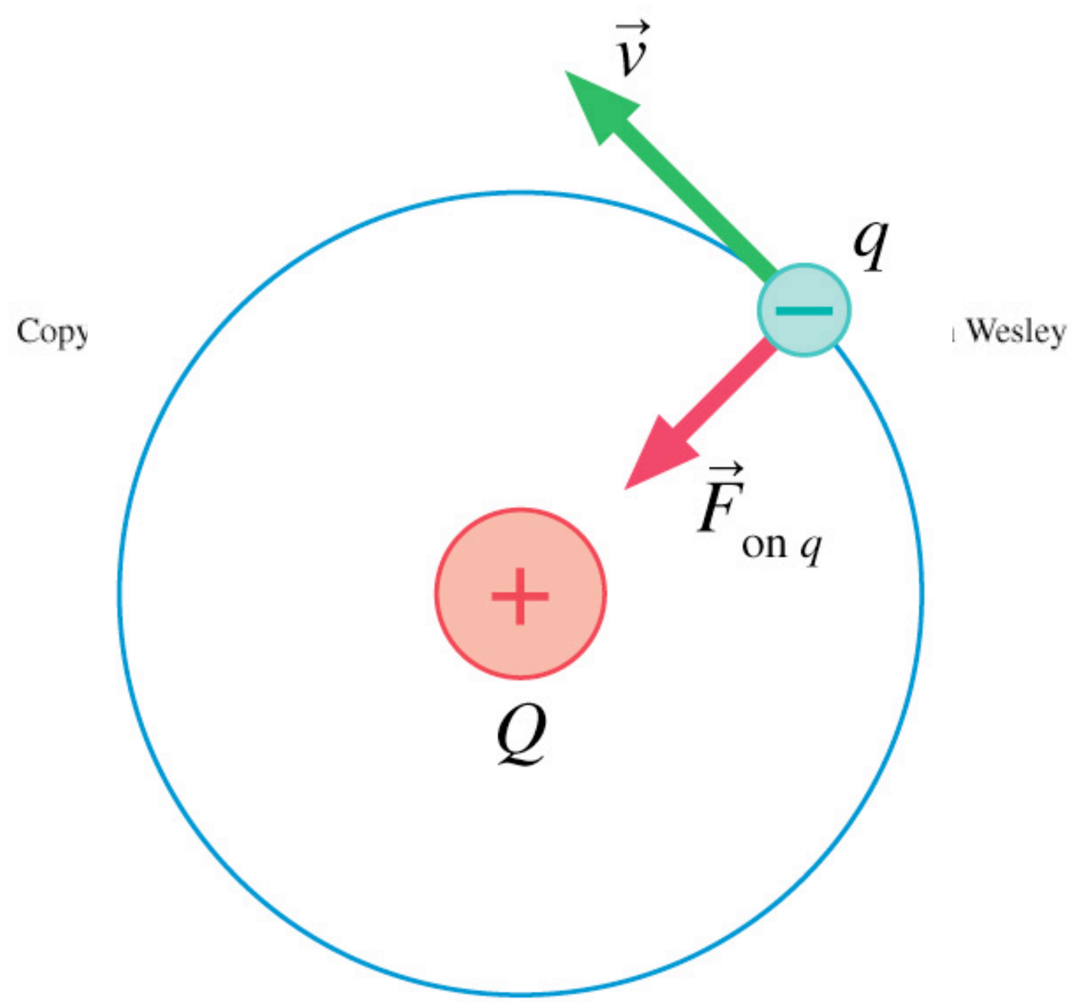
- Source charge creates E, other charges respond to it:

$$\bar{F}_{\text{on } q} = q\bar{E} \Rightarrow$$
$$\bar{a} = (q/m)\,\bar{E}$$




- Uniform E (a = constant): trajectory is parabola (as in gravitational field)

- Non-uniform field e.g. circular motion:



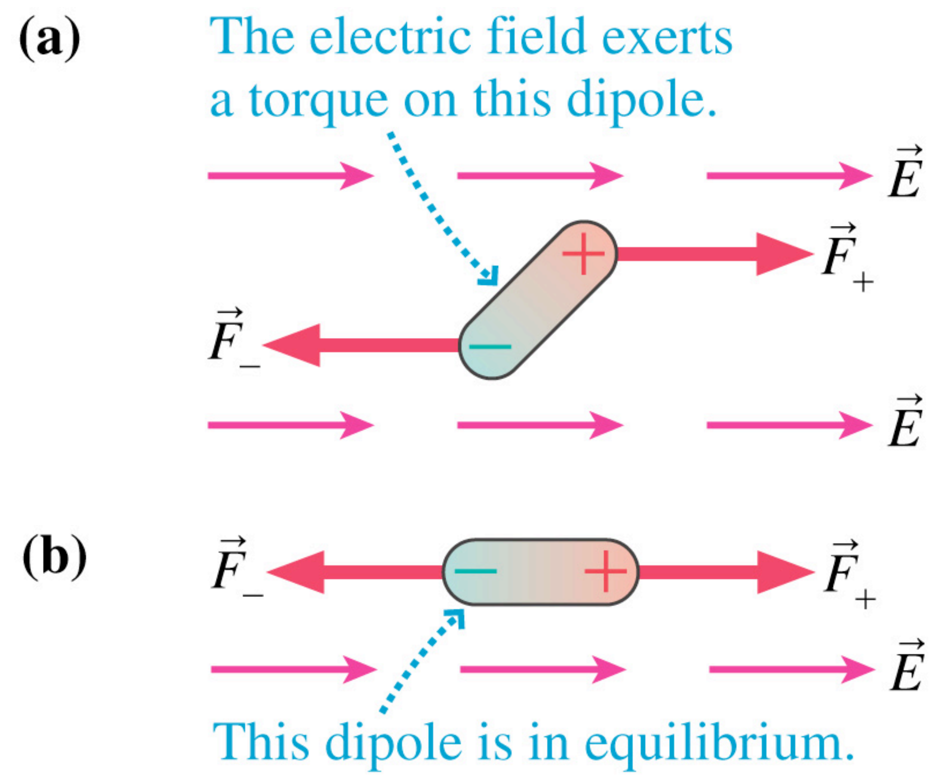



$$|q|E = \frac{mv^2}{r}$$

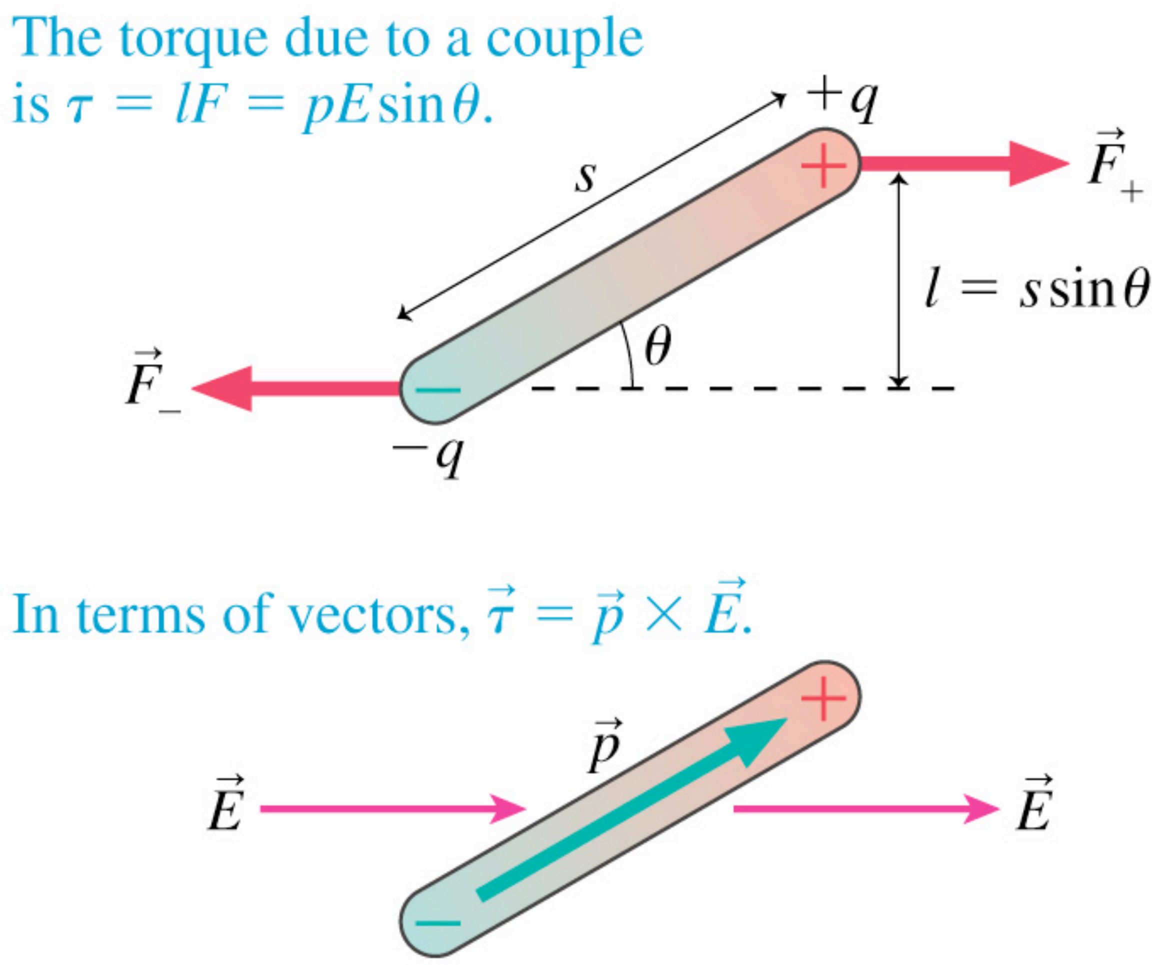
# Example

- The surface charge density on an infinite charged plane is $-2.0 \times 10^{-6}\ \mathrm{C/m^2}$. A proton is shot straight away from the plane at $2.0 \times 10^{6}\ \mathrm{m/s}$. How far does the proton travel before reaching its turning point?

# Motion of Dipole in Electric Field





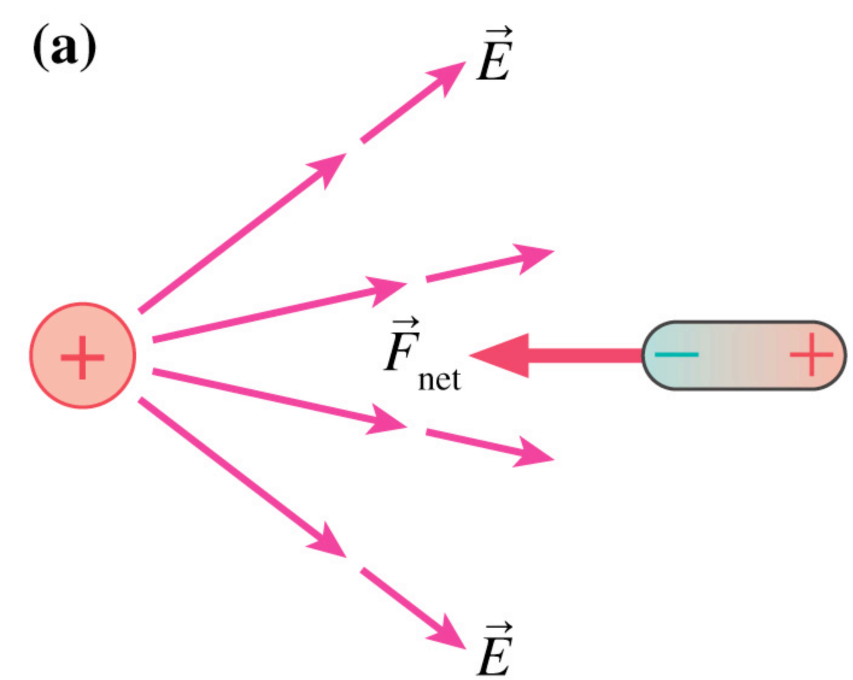






- Polarization force: external charge induced dipole; attractive force on near end > repulsive...charged object attracts neutral...

- Dipole in <u>uniform</u> E: no net force, but torque, causing it to rotate

- Dipole in <u>non</u>-uniform E: first aligns, net force toward stronger field (toward charged object)

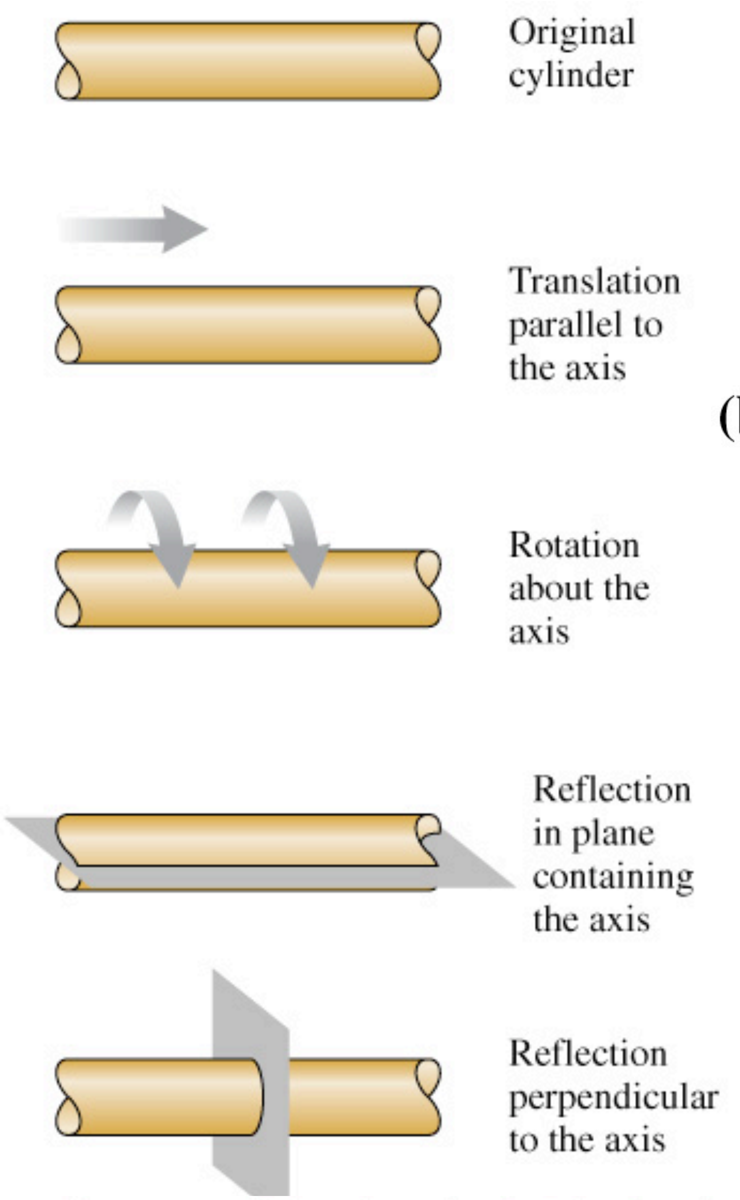


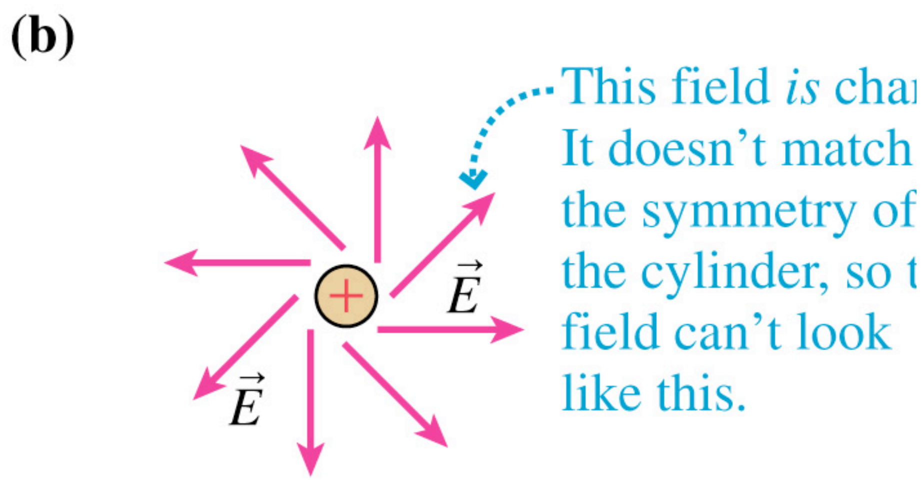
# Chapter 28 (Gauss' Law)

- Use symmetry to find geometry of $\bar{E}$
- For such fields, calculate $\bar{E}$ using Gauss's Law
- Concept of Electric Flux in Gauss's Law
- Use Gauss's Law to understand conductors

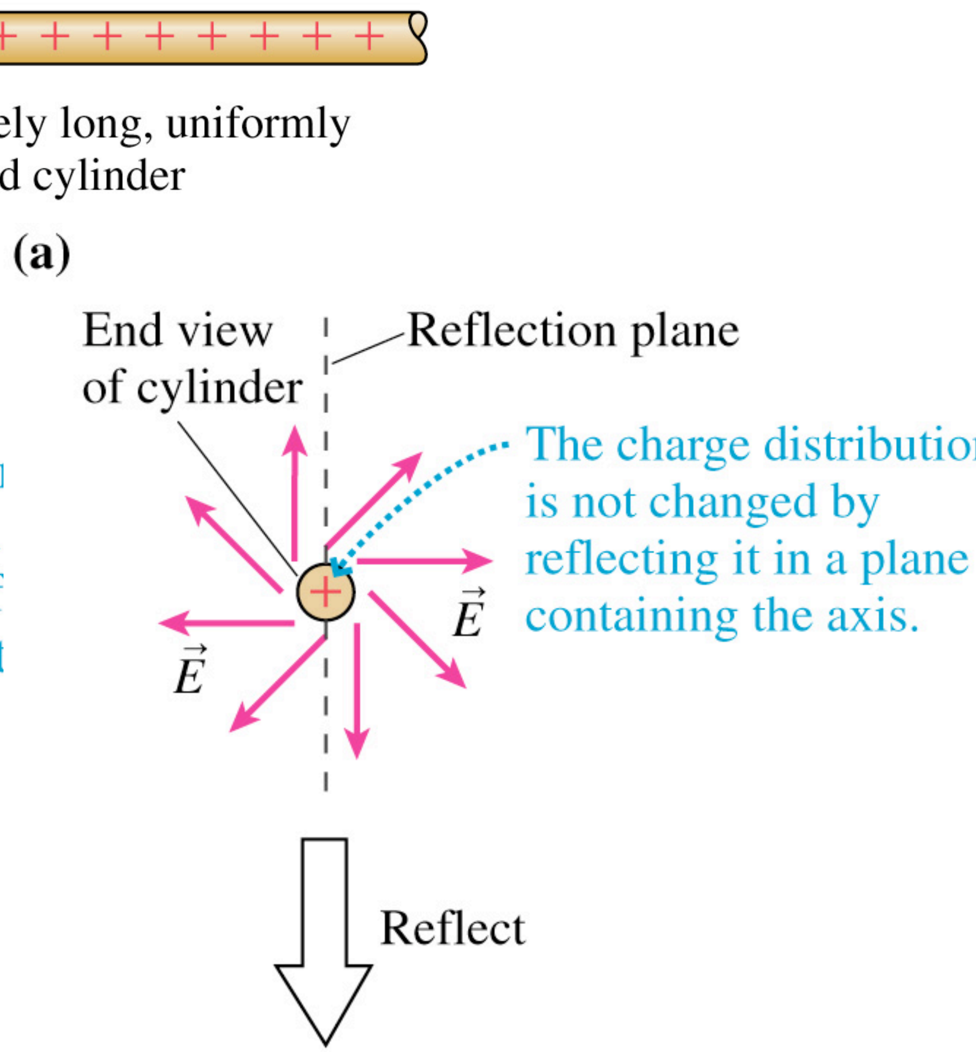
Today

# Symmetry (unchanged under geom. transformation )

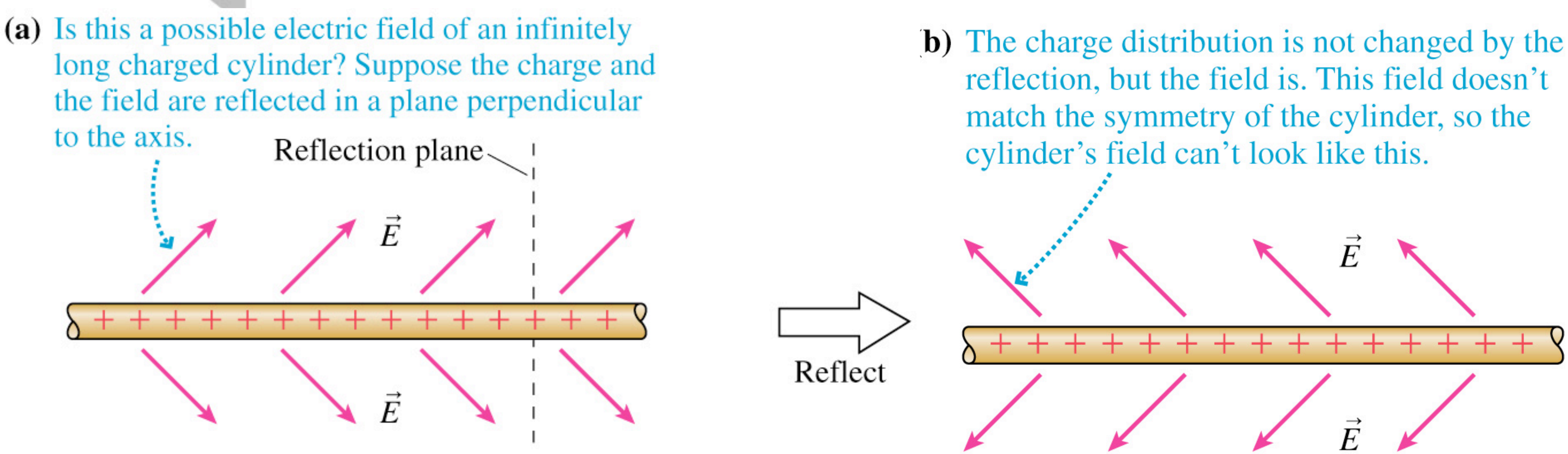




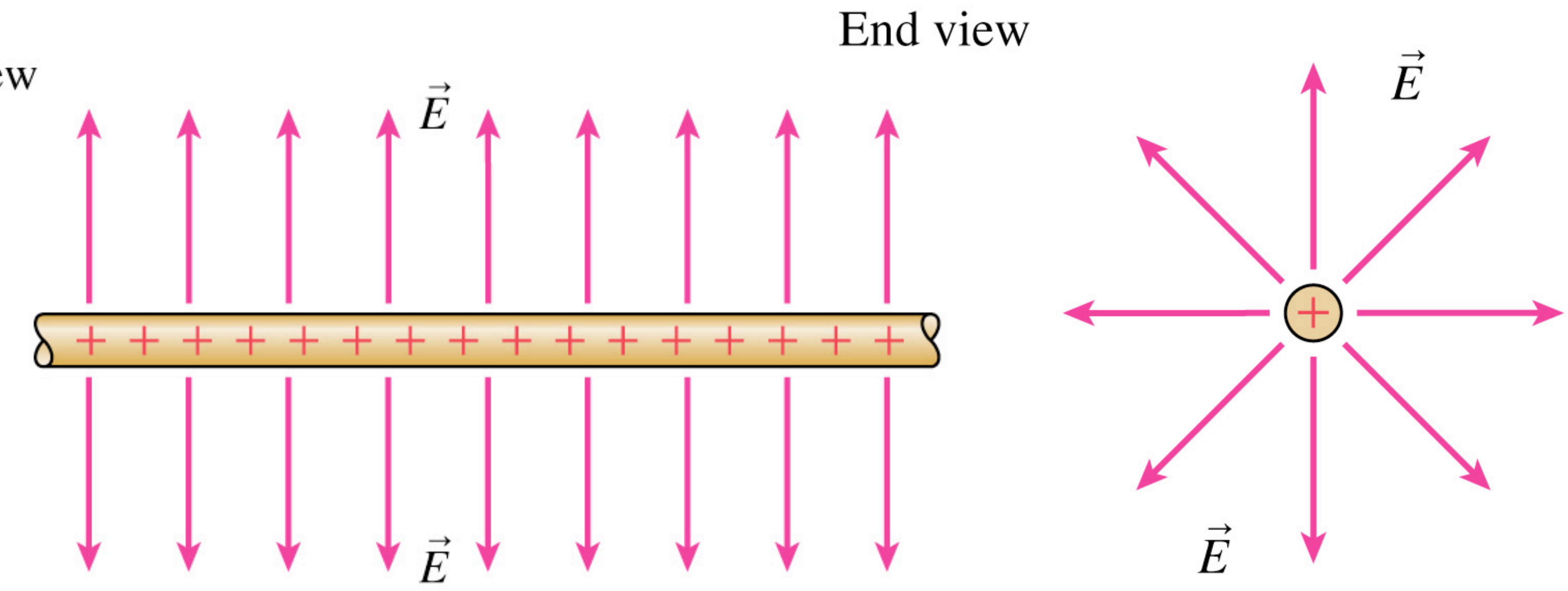





# Symmetry II

- must be...
- 3 fundamental symmetries

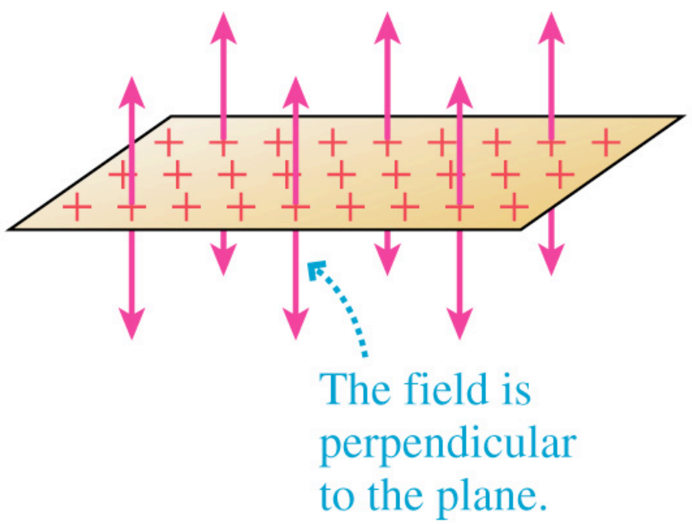



**Cylindrical symmetry**

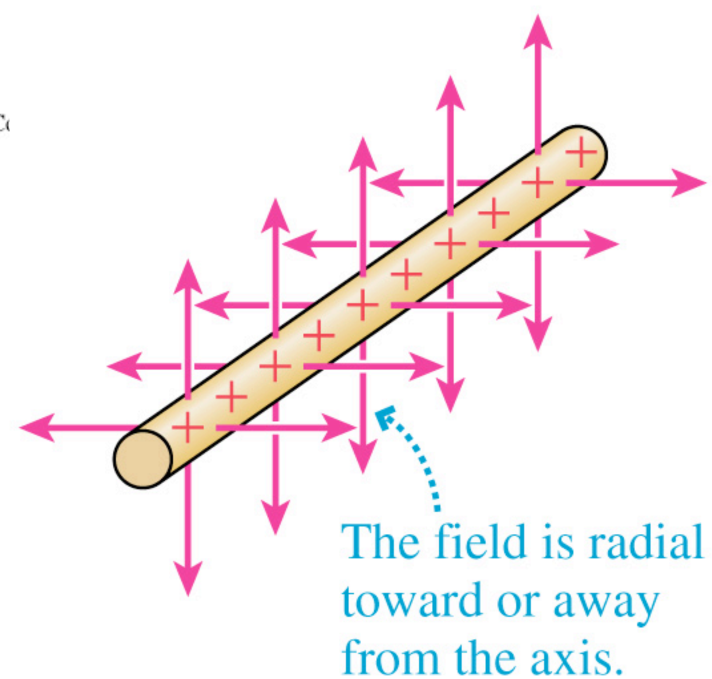


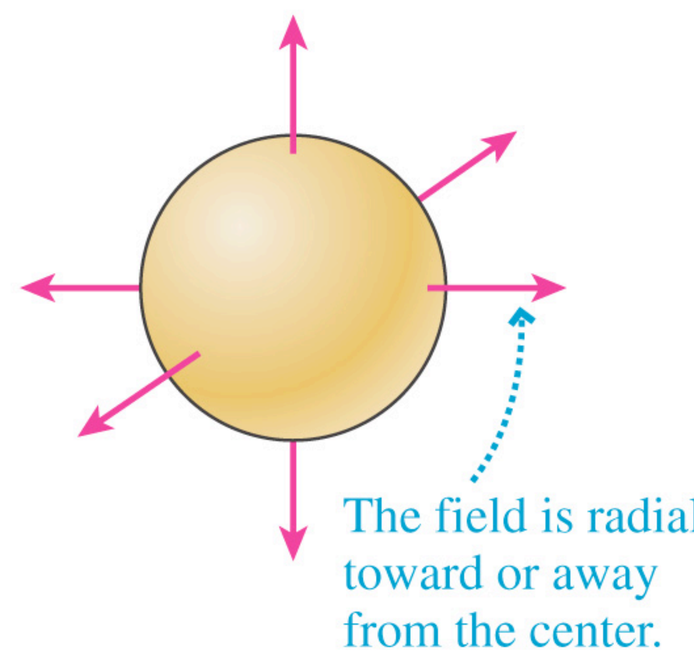
**Spherical symmetry**

**Planar symmetry**





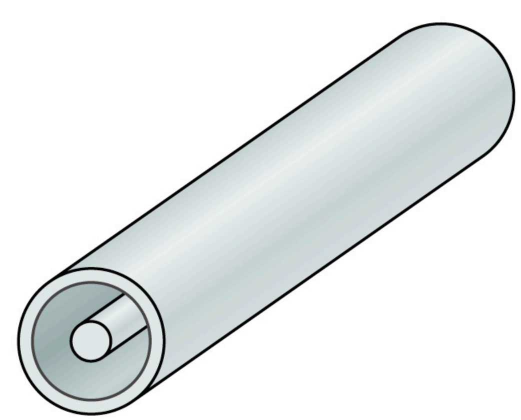





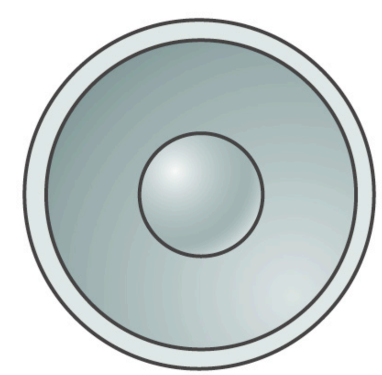



 More complex example:

Infinite parallel-plate capacitor

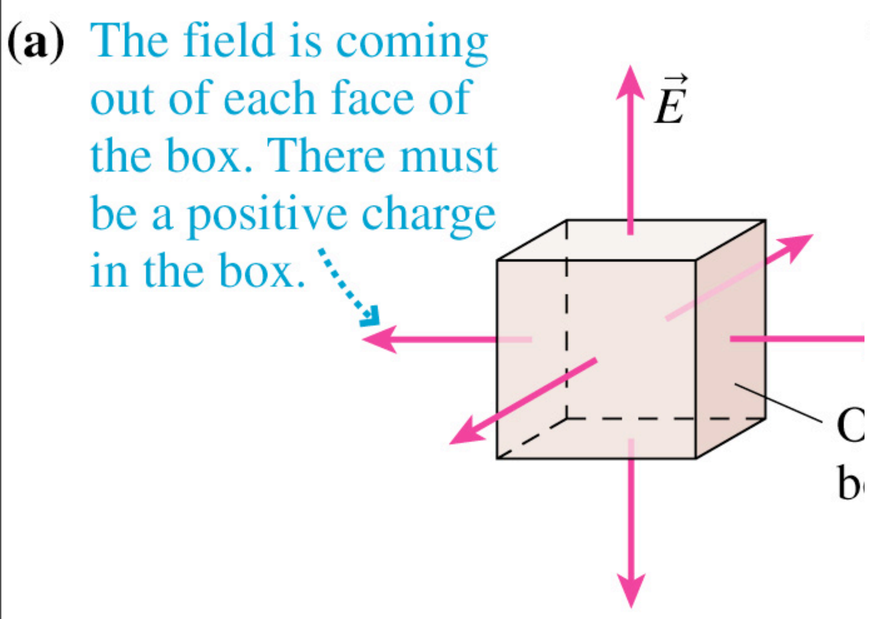


Coaxial cylinders

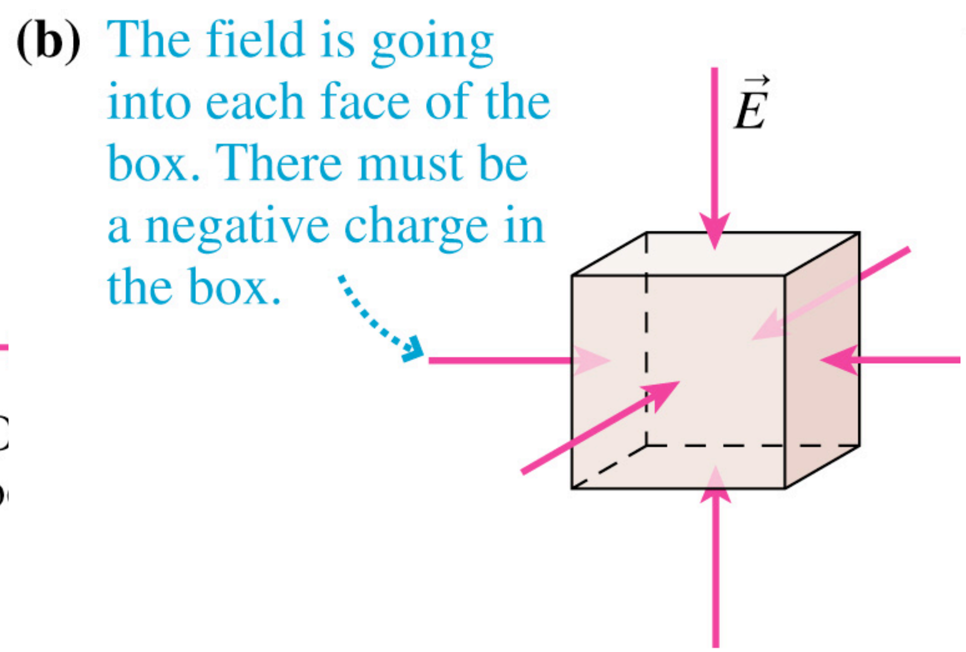


Concentric spheres

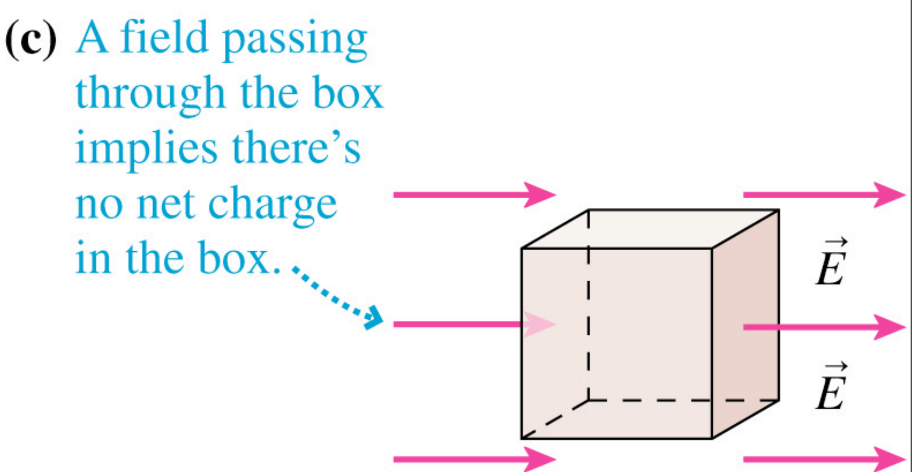
# Concept of Flux I







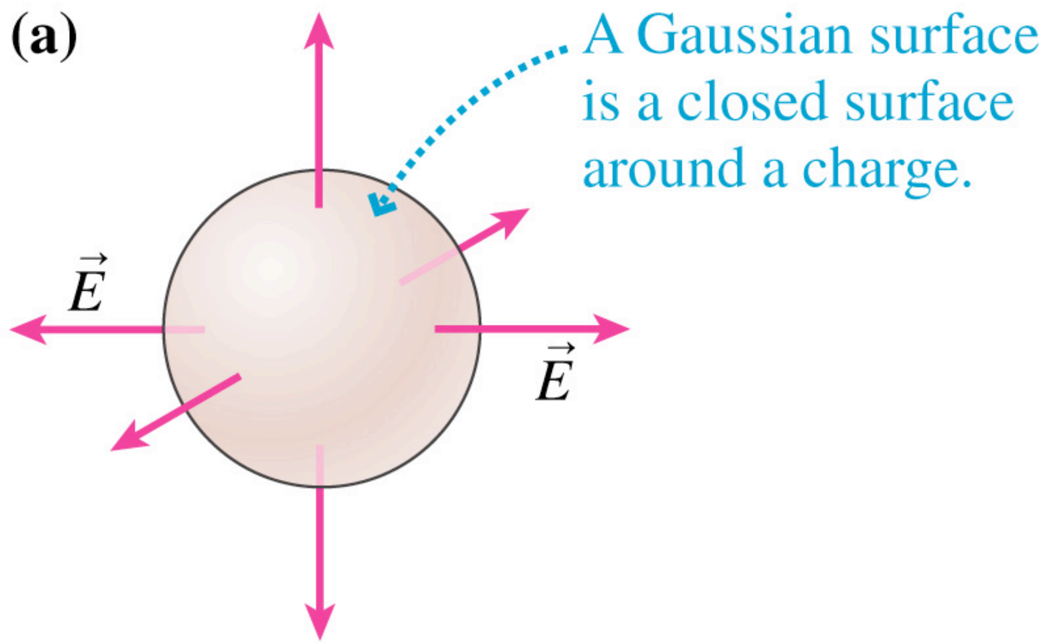




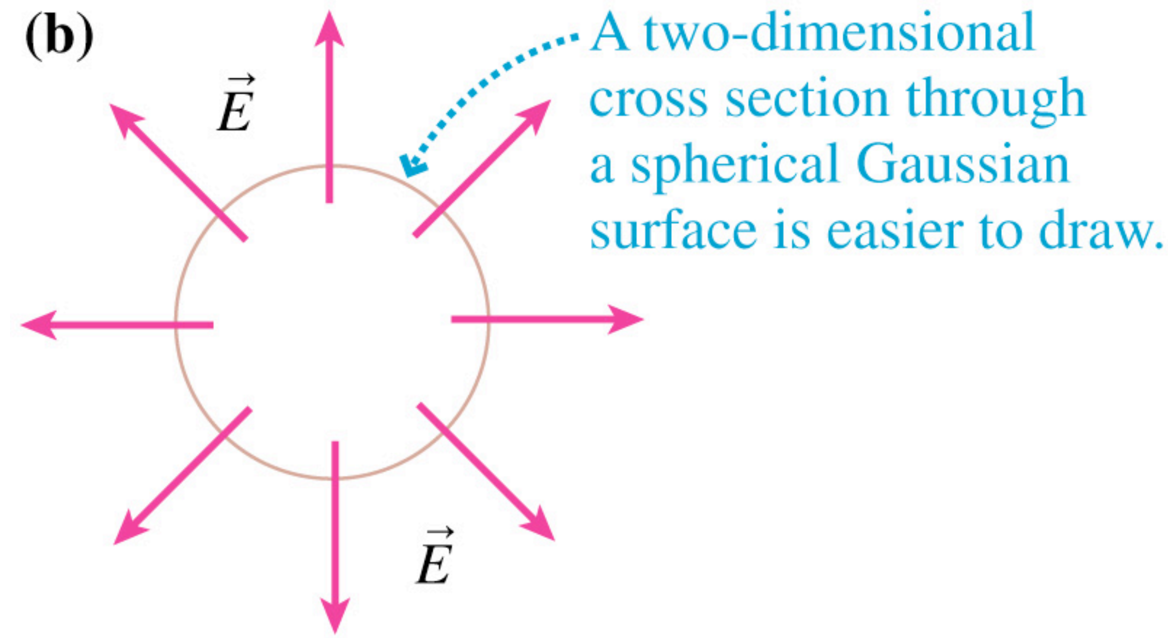


- outward <u>flux</u> ("flow") of $\bar{E}$ thru' closed (<u>Gaussian</u>) surface for next positive charge inside
- inward...for...negative...
- no <u>net</u> flux...<u>net</u> charge

# Concept of Flux II








- match closed surface to symmetry of $\bar{E}$ /charge distribution