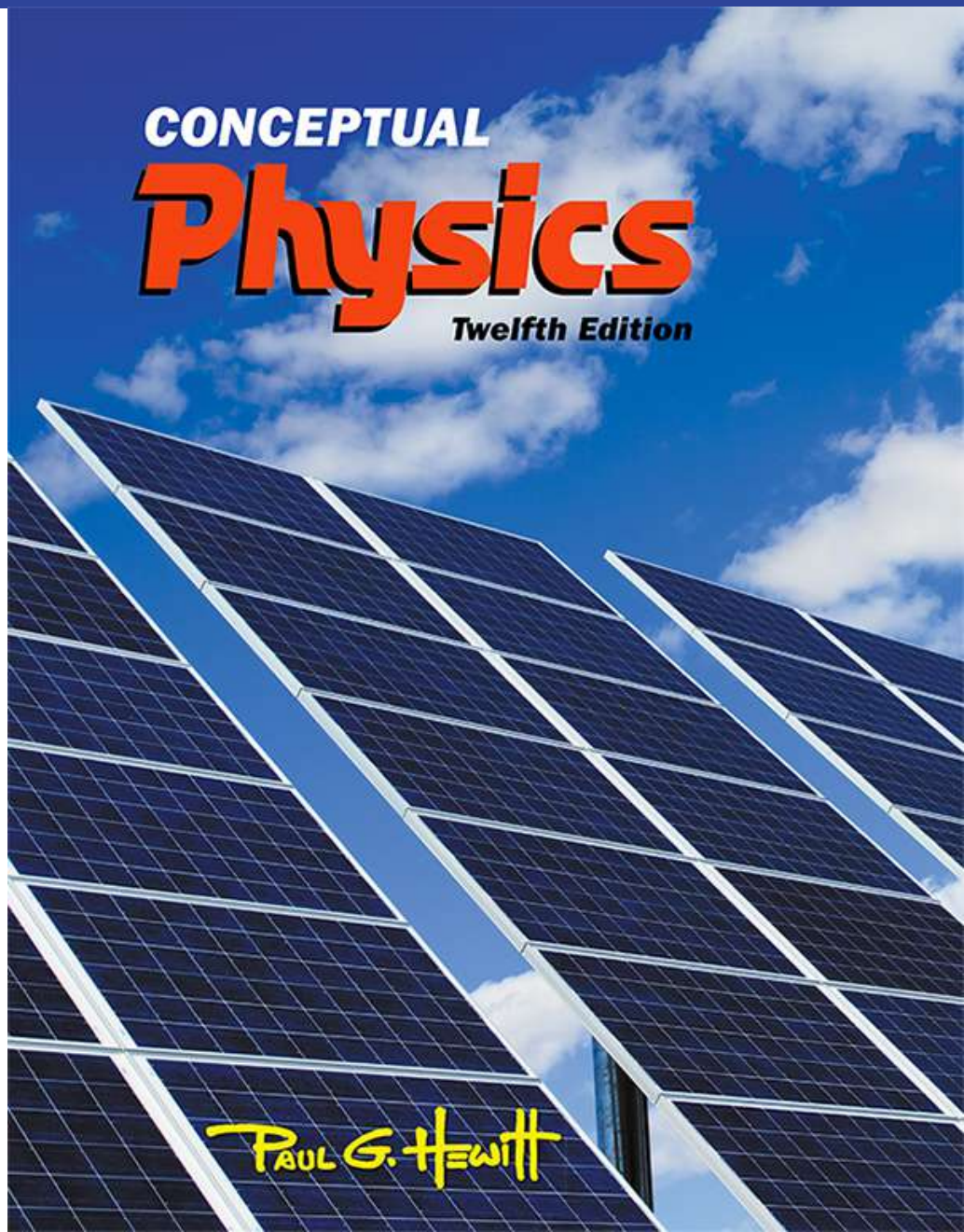
Lecture Outline

Chapter 22: Electrostatics

- Charge Polarization
- Electric Field

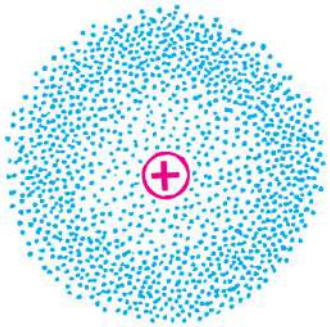


Charge Polarization

- One side of the atom or molecule is induced into becoming more negative (or positive) than the opposite side. The atom or molecule is said to be **electrically polarized.**
- An electron buzzing around the atomic nucleus produces an electron cloud.

a. The center of the negative cloud normally coincides with the center of the positive nucleus in an atom.

b. When an external negative charge is brought nearby to the right, the electron cloud is distorted so that the centers of negative and positive charge no longer coincide. The atom is now electrically polarized



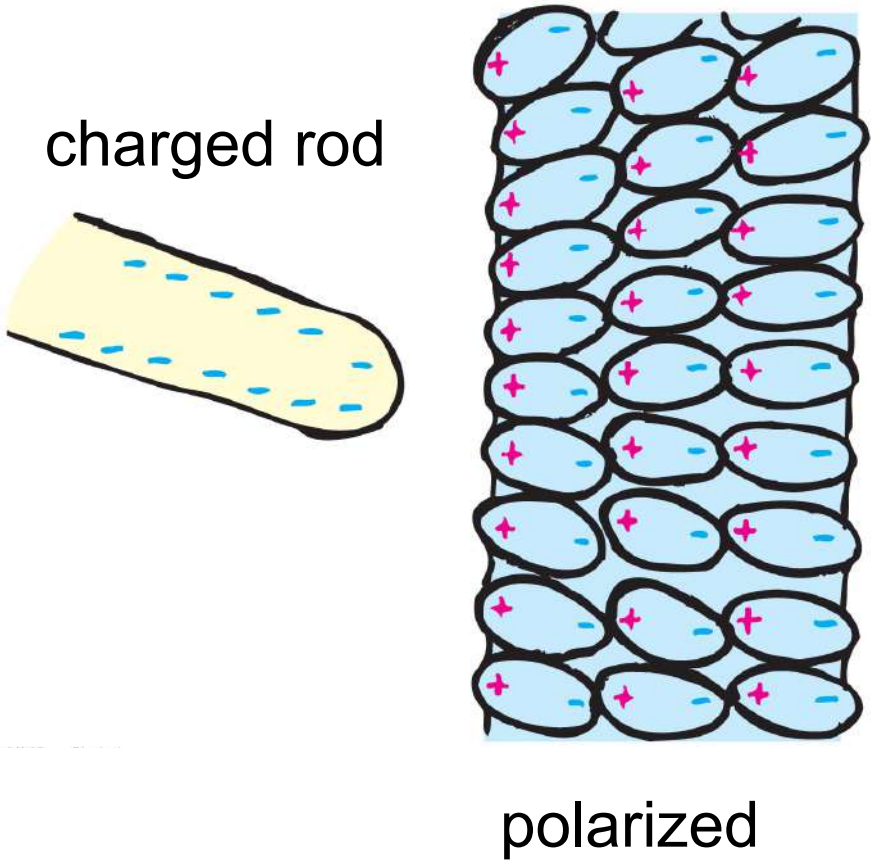
(a)

not polarized

polarized

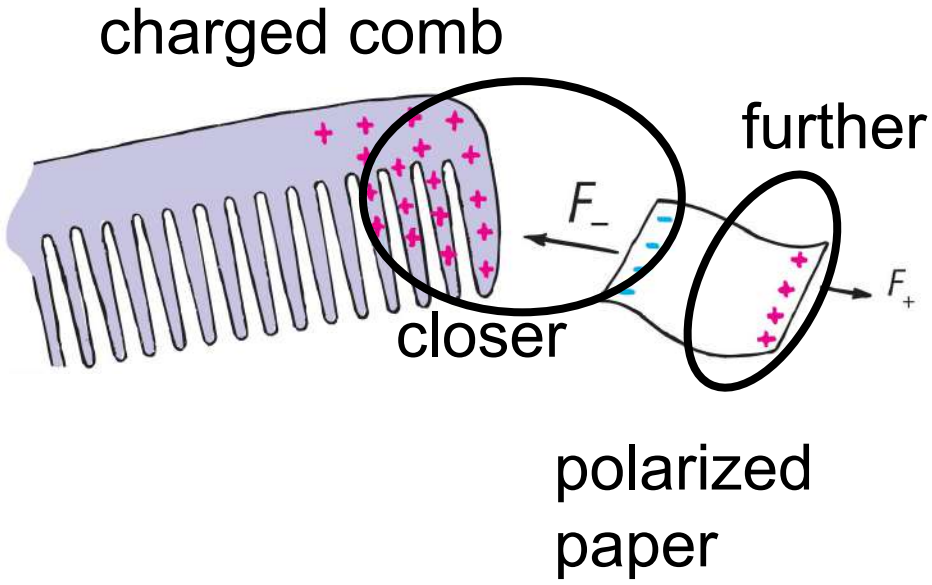
Charge Polarization, Continued

- If the charged rod is negative, then the positive part of the atom or molecule is tugged in a direction toward the rod, and the negative side of the atom or molecule is pushed in a direction away from the rod.
- The positive and negative parts of the atoms and molecules become aligned. They are electrically polarized.



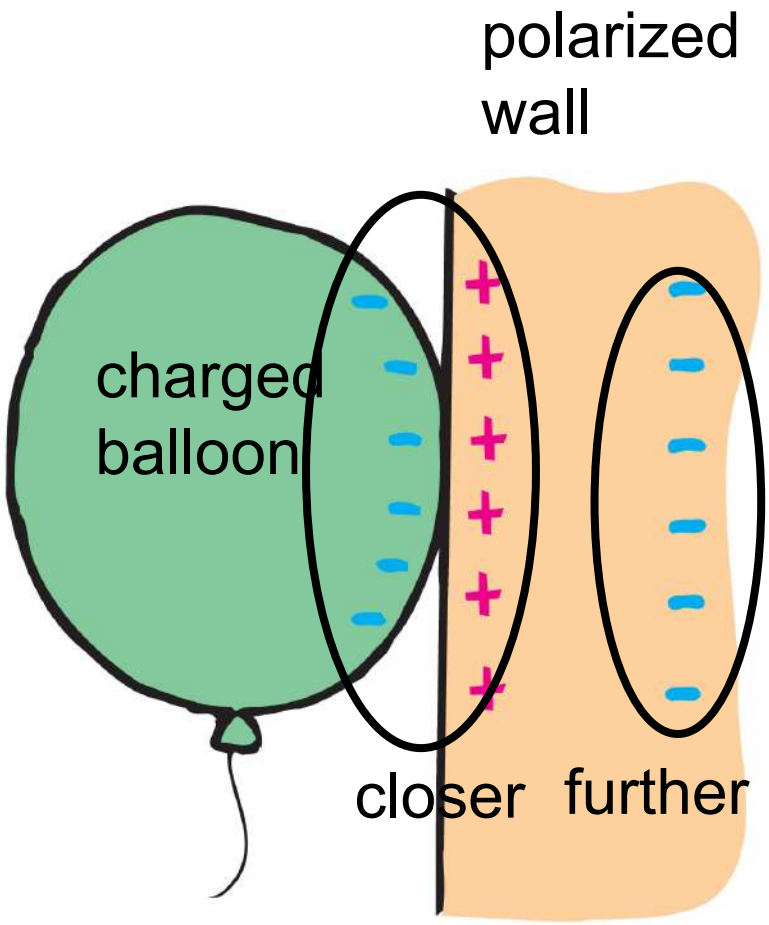
Charge Polarization, Continued-1

- When a charged comb is brought nearby, molecules in the paper are polarized.
- The sign of charge closest to the comb is opposite to the comb's charge.
- Charges of the same sign are slightly more distant.
- Closeness wins, and the bits of paper experience a net attraction.



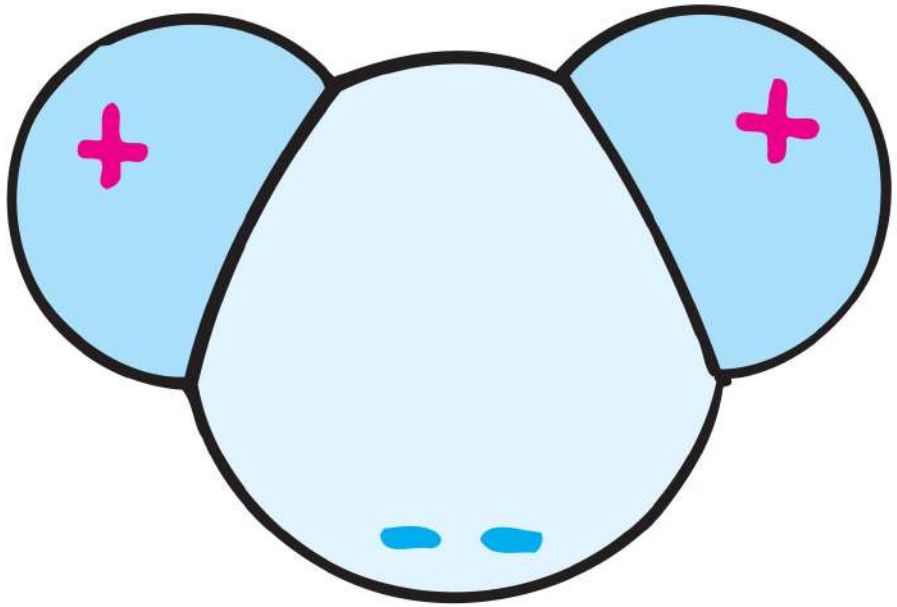
Charge Polarization, Continued-2

- Rub an inflated balloon on your hair, and it becomes charged.
- Place the balloon against the wall, and it sticks.
- This is because the charge on the balloon *induces* an opposite surface charge on the wall.
- Again, closeness wins, for the charge on the balloon is slightly closer to the opposite induced charge than to the charge of same sign



Charge Polarization, Continued-3

- Many molecules—H_2O, for example—are electrically polarized in their normal states.
- The electric charge is separated within it:
- → This is a dipole.

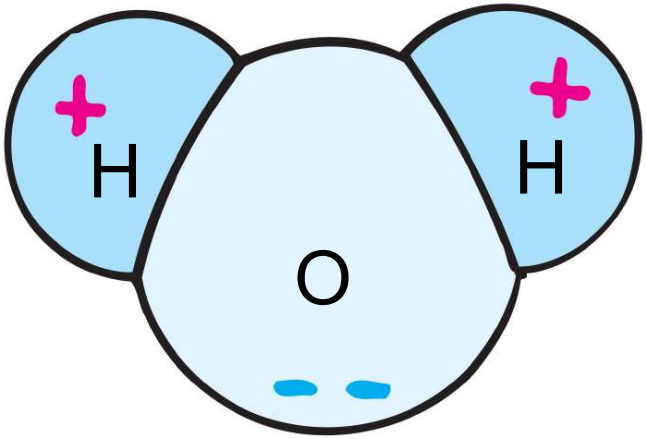


The molecule is neutral. But, there is a little more negative charge on one side of the molecule than the other.

Charged objects vs. Polarized ones:

Compare water (H_2O) with ions like Na+ and Cl-

water

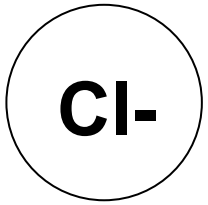


net charge = 0

but molecule is polarized.

ions:

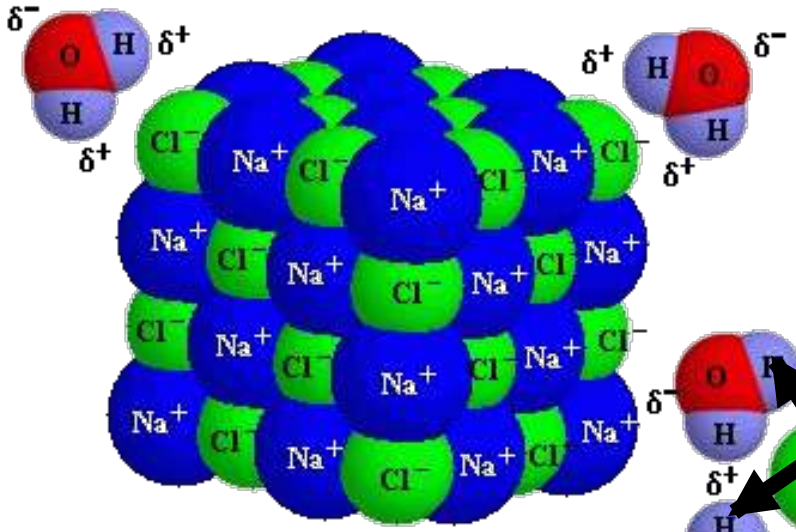
net charge = +1



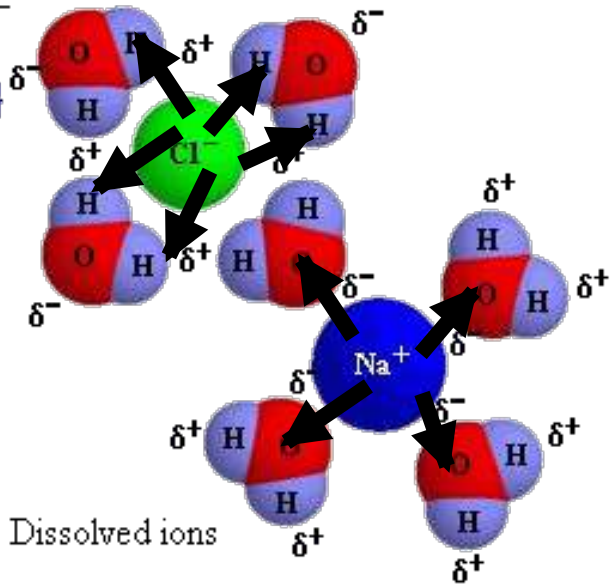
net charge = -1

Why does salt (NaCl) dissolve in water?

The charged ions Na^+ and Cl^- are surrounded by the polarized H_2O dipoles:



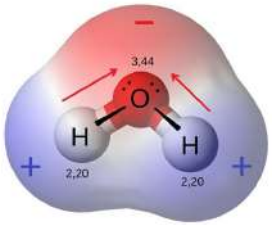
The negative Cl- attracts the +H of H_2O.

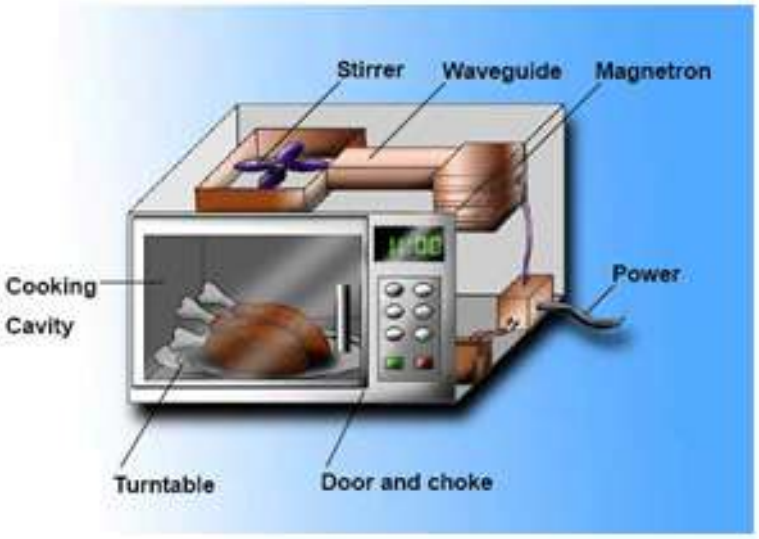


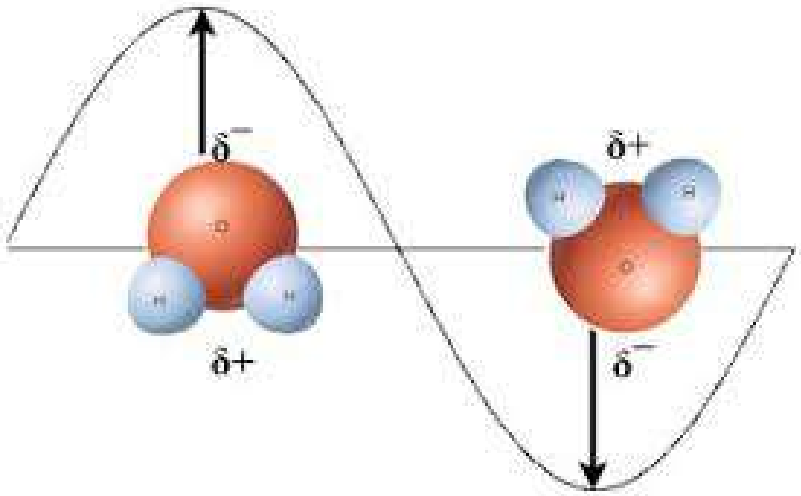
The positive Na+ attracts the - O of H_2O.

How a microwave oven works:

A microwave oven creates a rapidly changing electric field. The field makes the **polar water molecules** flip back and forth. This heats up anything that has water in it, but does not heat paper,etc.







Take out a sheet of paper. Write your name at the top. Copy down the answers…

21. In terms of net charge, how does an electrically *polarized* object differ from an electrically *charged* object?

22. What is an electric dipole?

23. Give an example of a common electric dipole.

- Electric field E

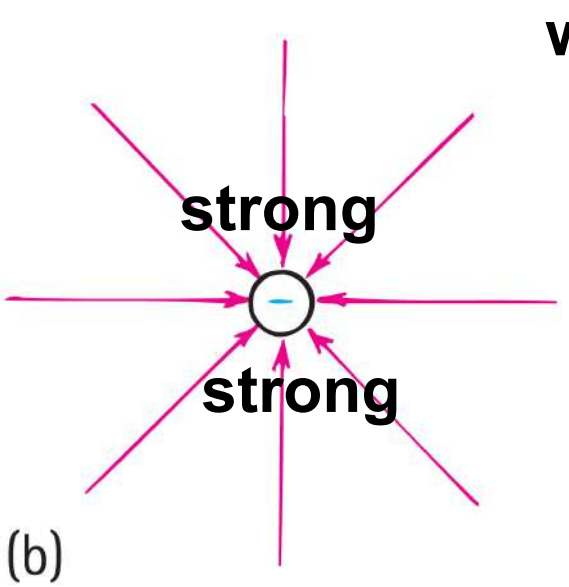
→ Fields explain how forces act *without touching*

  - Space surrounding an electric charge = an "aura"
    The lines are *lines of electric force*
  - Stronger when closer in

  → lines closer together

  - Weaker when further away

  → lines more spread out



Strength of the electric field E

The strength of E is found by measuring the force F that the charge exerts on a positive **test** charge q.

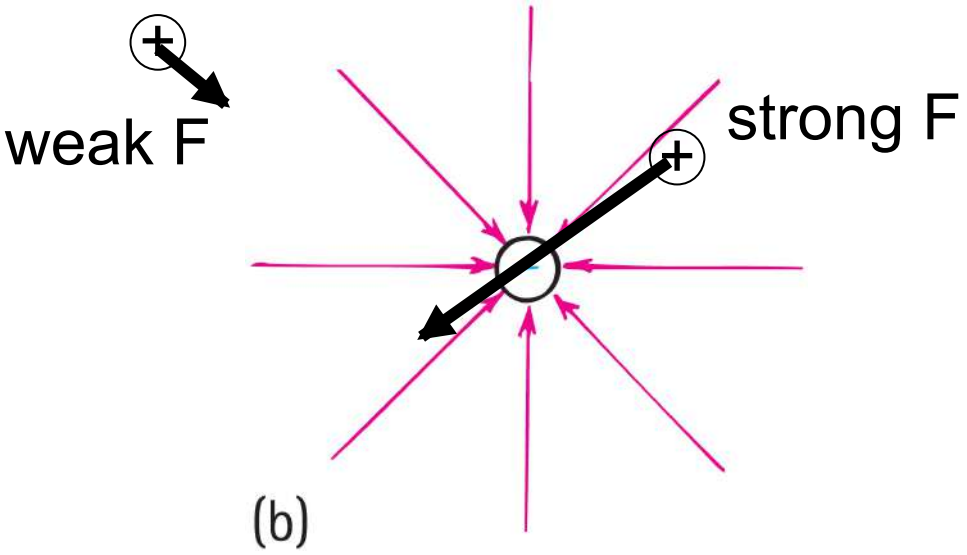
→ It is the force per unit charge

⊕ = test charge q

$$E = \frac{electric\ force}{charge} = \frac{F}{q}$$

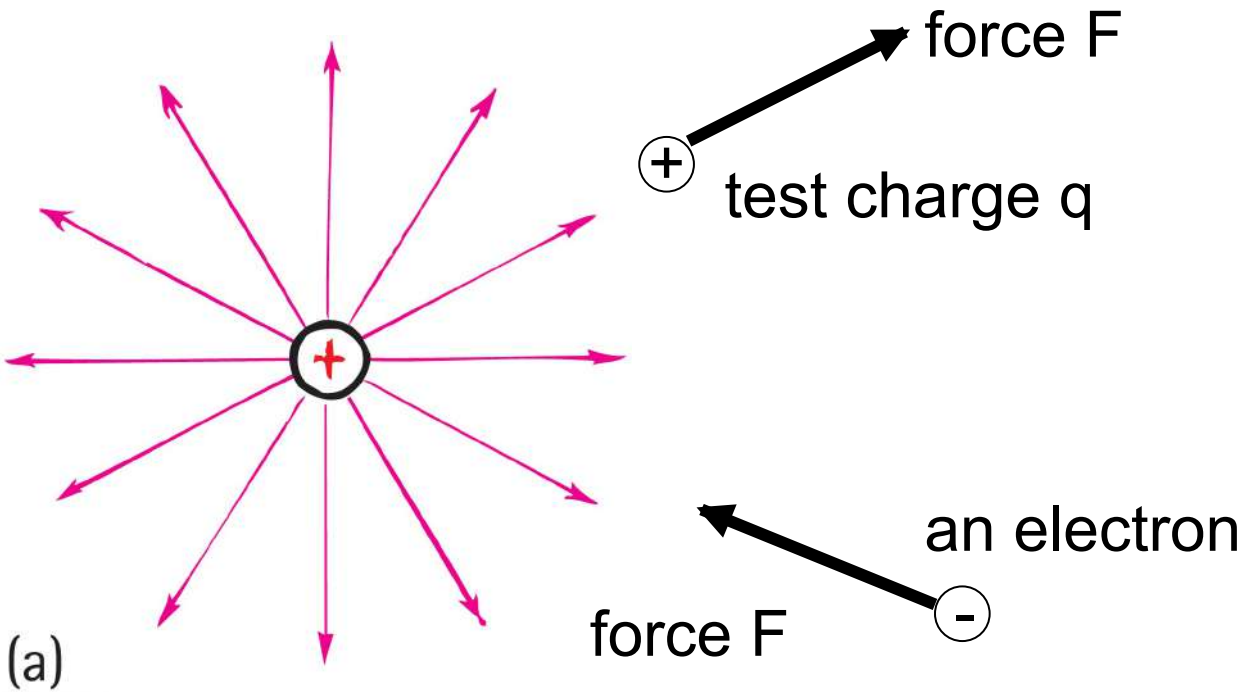
→ more F

→ stronger E



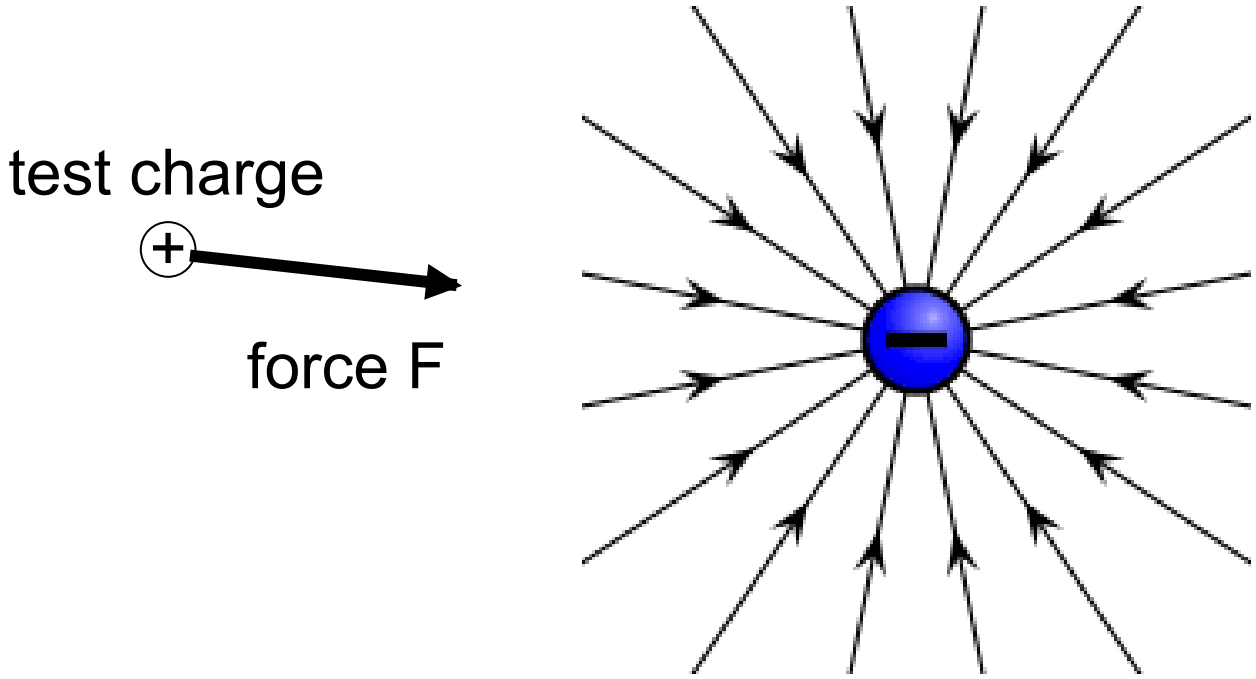
Electric Field, Continued

- Electric field **direction**
  - Same direction as the force on a ***positive*** charge
  - Opposite direction to the force on an electron



E field around a *negative* charge

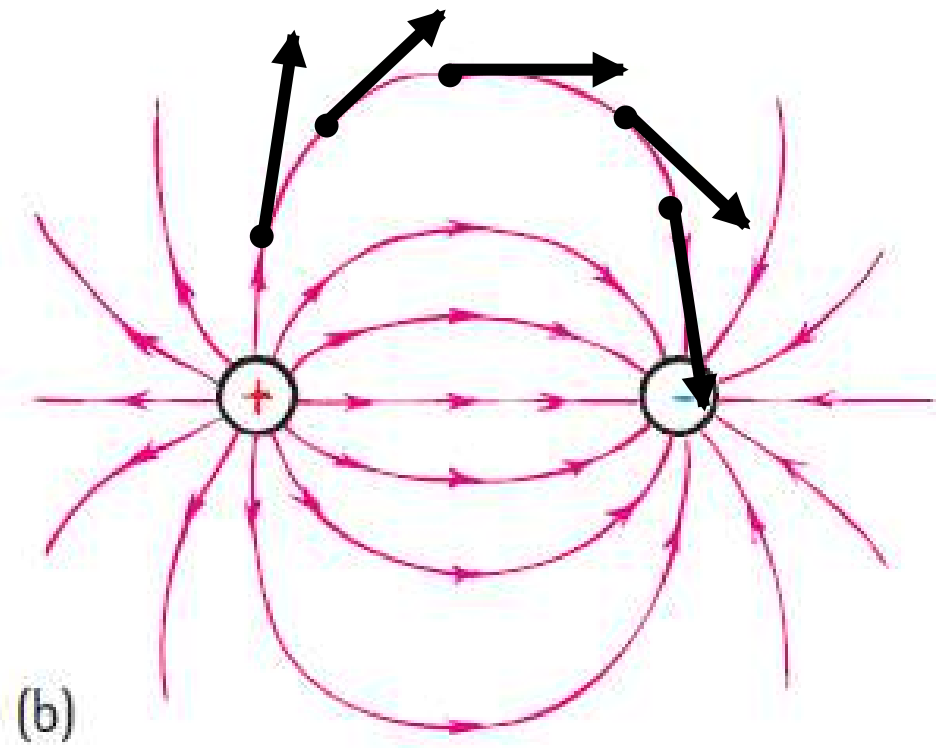
Test field by bringing a *positive* test charge nearby.



Force is inward. So field (force) lines are inward around a negative charge.

Electric field between 2 *opposite* charges:

At any point, the electric force F is *tangent* to the line.

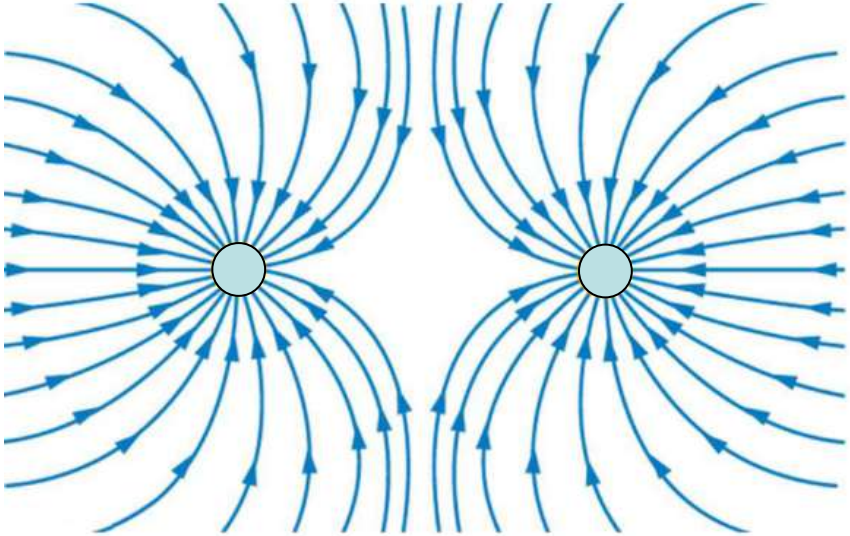


Which charge do lines come out of? +

Which charge do lines go into? -

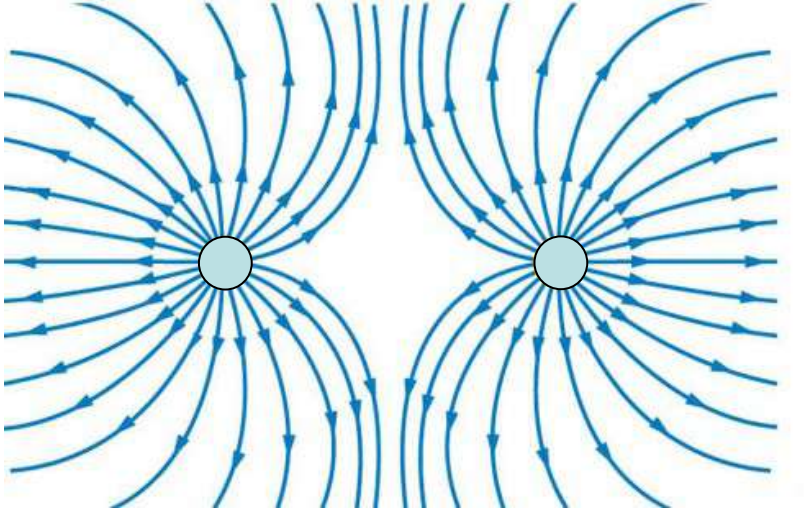
E field between like charges

What kind of charges?



2 negative charges
lines go into both

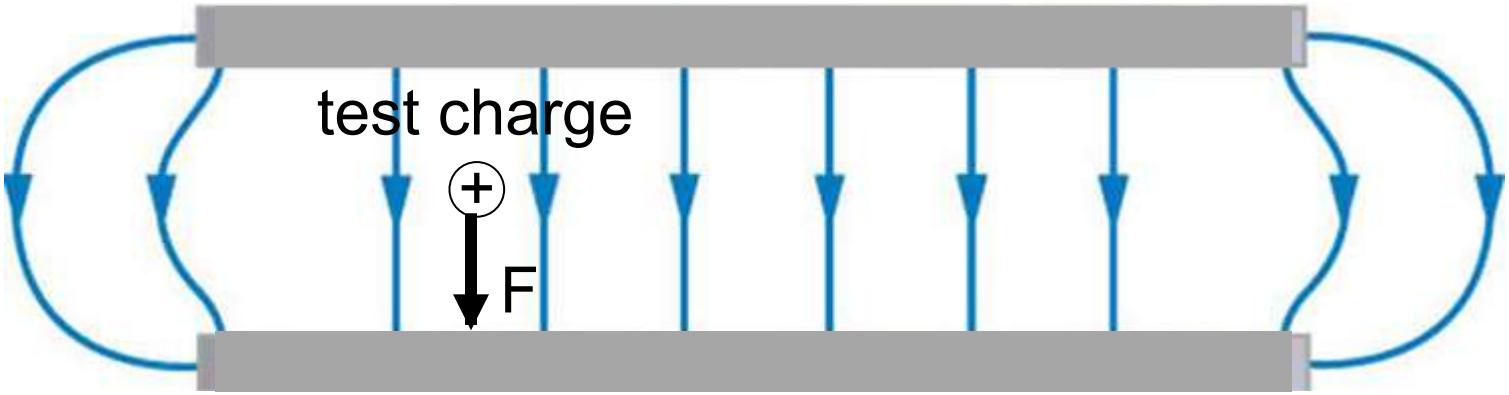
What kind of charges?



2 positive charges
lines come out of both

Do field lines ever cross? No

Electric field between parallel plates:



Is the top plate positively or negatively charge? +

What direction is force on the + test charge ? down

How can you tell that the electric field is (mostly) constant between the plates? lines equally spaced

Electric Shielding

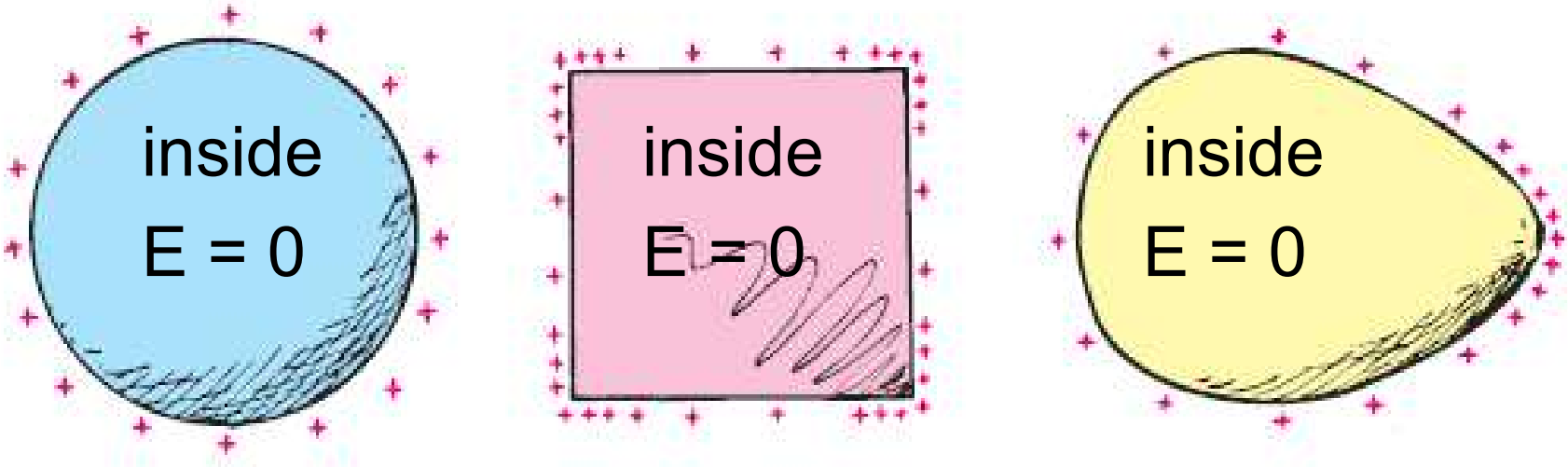
The electric field in a **metal** container = 0, even if:

1) there is an electric field outside of it; and,

2) there are charges on the outside.

→ The charges stay on the outside

→ The charges tend to collect at corners:



Shielding is useful because….

1) …you are safe if lightning strikes a metal car

FIGURE 22.21
Electrons from the lightning bolt mutually repel to the outer metal surface. Although the electric field the electrons set up may be great *outside* the car, the net electric field *inside* the car is zero.

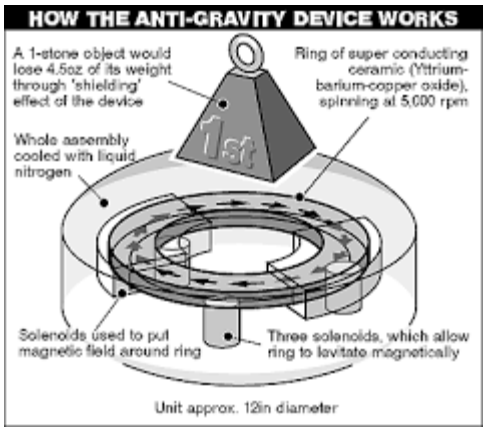
2) …coax cable has a metal braid that protects the electrical signal inside it

Shielding is useful because….

3. electrical components can be protected by a metal inside cover

4. aliens can't read your thoughts if you wear a hat made out of aluminum foil

BUT…unfortunately…you cannot shield gravitational fields…



On your homework, continue to answer…

24. Give two examples of common force fields.

25. How is the direction of an electric field defined?

26. Why is there no electric field at the center of a charged spherical conductor?

The field from close charges cancels the field from charges on the opposite side.

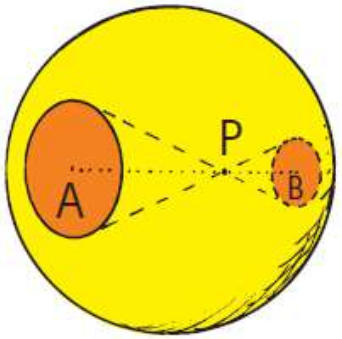


FIGURE 22.19
The test charge at P is attracted just as much to the greater amount of charge at farther region A as it is to the smaller amount of charge at closer region B. The net force on the test charge is zero—there, and anywhere inside the conductor. The electric field everywhere inside is also zero.

27. When charges mutually repel and distribute themselves on the surface of conductors, what becomes of the electric field inside the conductor?

Turn your classwork in now.