PHYSICS II

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Electric Charge and Electric Field

Introduction

- Water pervades the science of chemistry and biology. It's not only what we drink when we're thirsty, but it's been called "the universal solvent."
- Even if we were to only look at water, and water as a solvent, we would see a simple problem like salt dissolving in water is the interaction of electrostatic charges, of ions and dipoles.

Electric charge

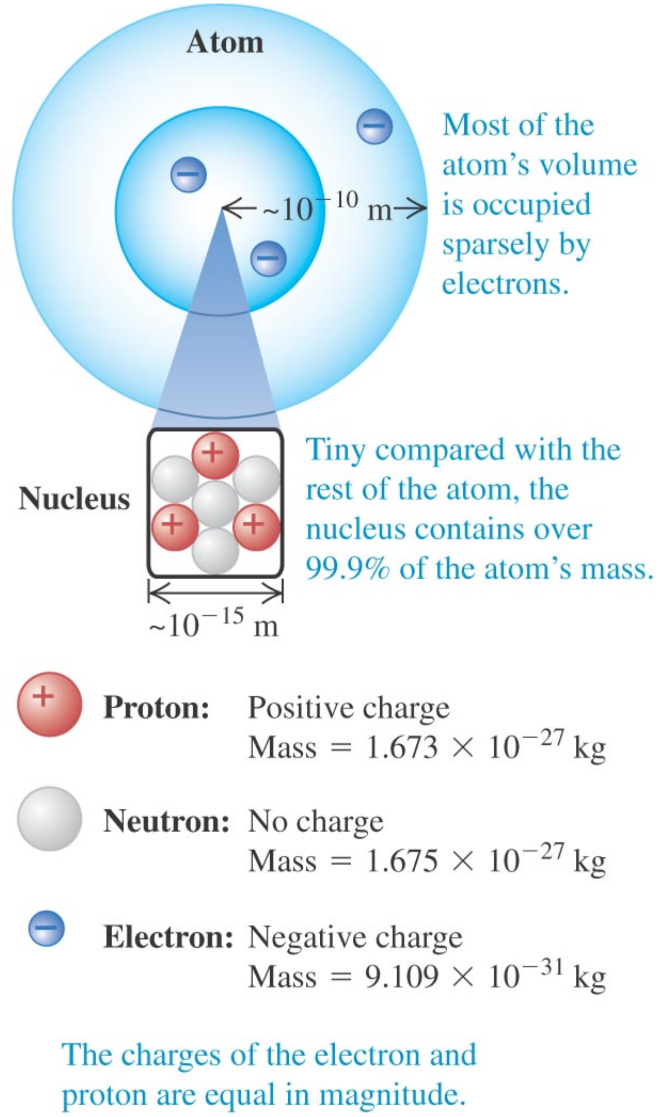
- Glass rods, plastic tubes, silk, and fur can be used to demonstrate the movement of electrons and how their presence or absence make for powerful forces of attraction and repulsion.

Ex: The photocopier

- The world may have come to take copiers for granted, but they are amazing devices. They use charge to hold fine dust in patterns until the pattern may be transferred to paper and made permanent with heat.

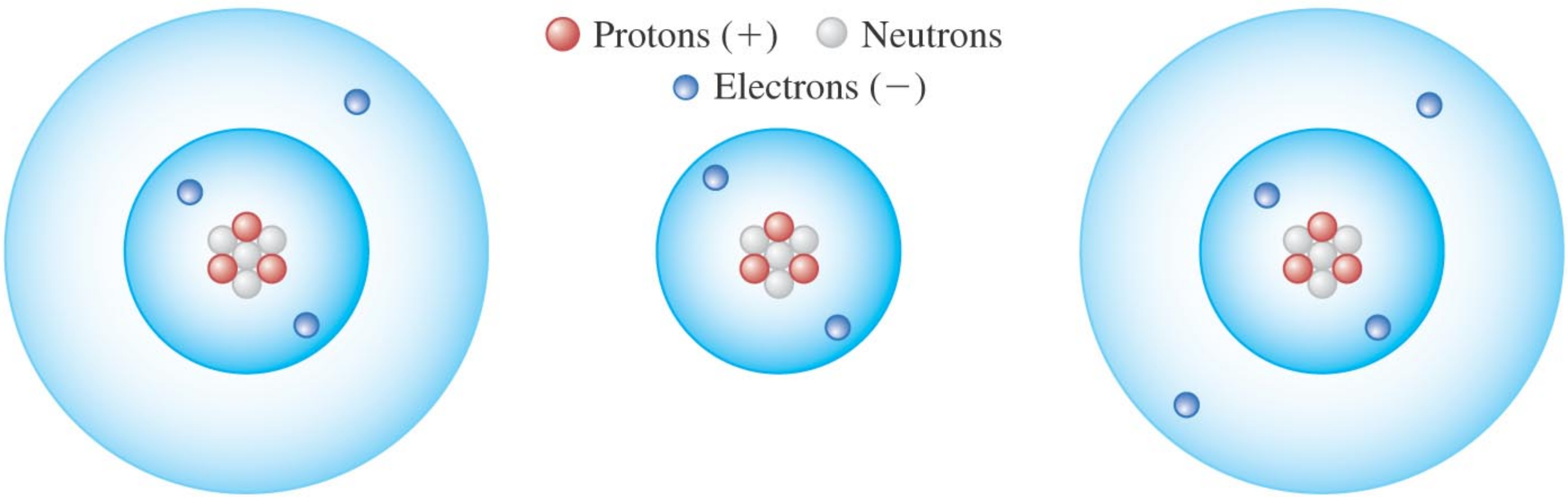
How is the atom arranged? Why is it easiest to move electrons?

- Visualize a football stadium as an atom. Electrons would be garden peas in the highest seats with charge of −1. Protons would be basketballs or melons with charge of +1, and neutrons would reside about the protons with no charge. All of the protons and neutrons could be in a small basket on the 50-yard line.



Consider lithium as a cation, an anion, and a neutral

- Let's study the subatomic arrangement of lithium with all charges balanced and the way only electrons move to make the atom an ion (+ or −).



(a) Neutral lithium atom (Li):

3 protons (3+)
4 neutrons
3 electrons (3−)

Electrons equal protons:
Zero net charge

(b) Positive lithium ion (Li^+):

3 protons (3+)
4 neutrons
2 electrons (2−)

Fewer electrons than protons:
Positive net charge

(c) Negative lithium ion (Li^-):

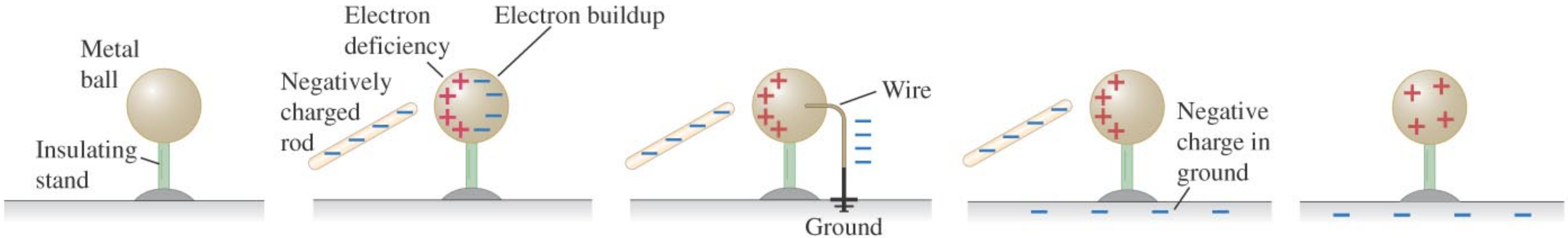
3 protons (3+)
4 neutrons
4 electrons (4−)

More electrons than protons:
Negative net charge

Electrons move freely and charges may be induced

- If you rub the balloon vigorously on a fuzzy sweater then bring the balloon slowly toward a painted concrete or plaster wall, the balloon will stick to the wall and remain for some time.

- The electrostatic force between static electrons and the induced positive charge in the wall attract more strongly than the weight of the balloon.



(a) Uncharged metal ball

(b) Negative charge on rod repels electrons, creating zones of negative and positive **induced charge**.

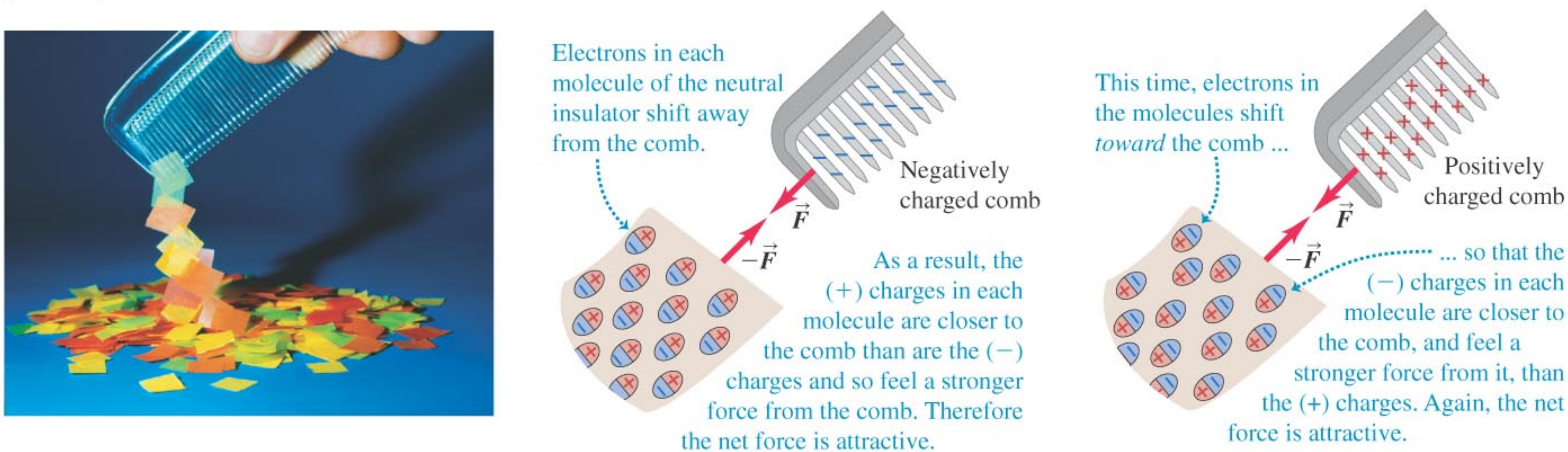
(c) Wire lets electron build-up (induced negative charge) flow into ground.

(d) Wire removed; ball now has only an electron-deficient region of positive charge.

(e) Rod removed; electrons rearrange themselves, ball has overall electron deficiency (net positive charge).

Static electricity about an insulator can shift

- The motion of static charges about a plastic comb and light bits of paper can cause attractive forces strong enough to overcome the weight of the paper.



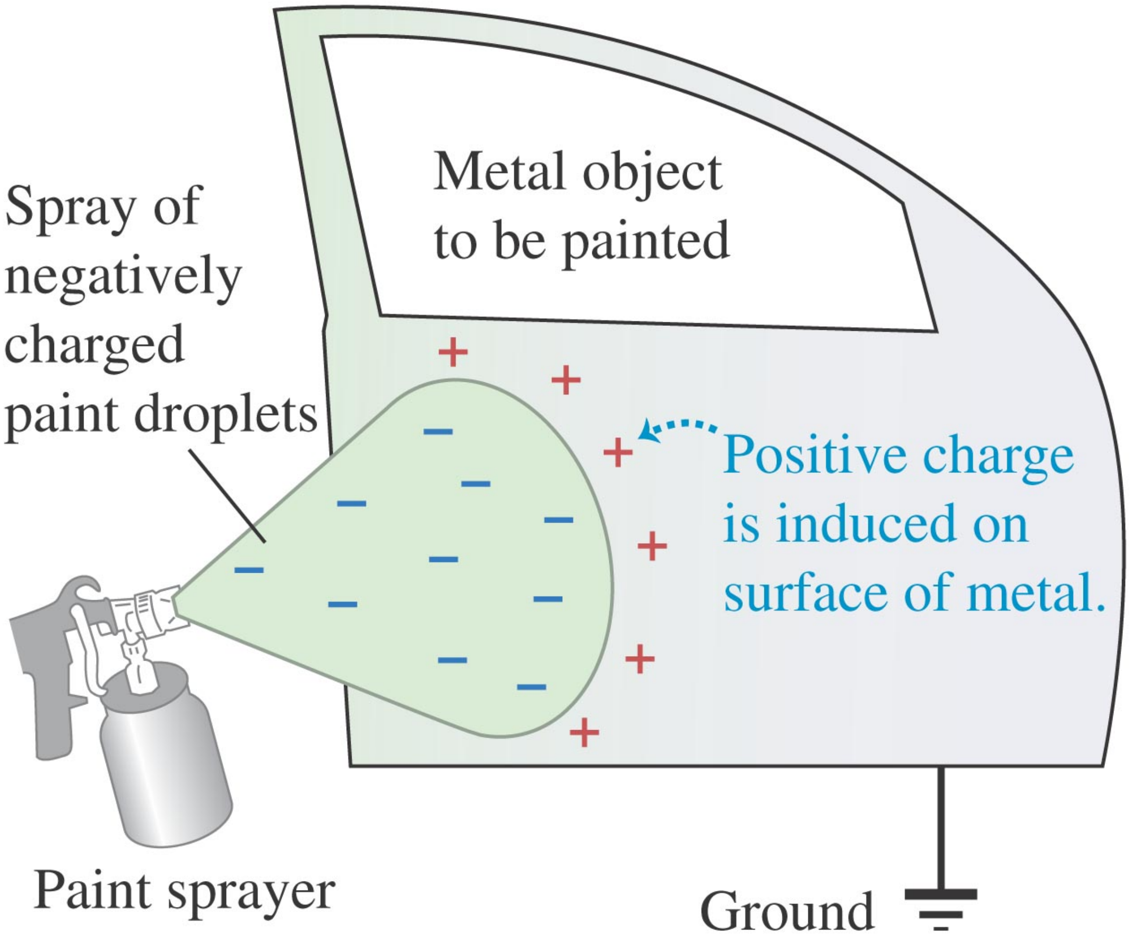
(a) A charged comb picking up uncharged pieces of plastic

(b) How a negatively charged comb attracts an insulator

(c) How a positively charged comb attracts an insulator

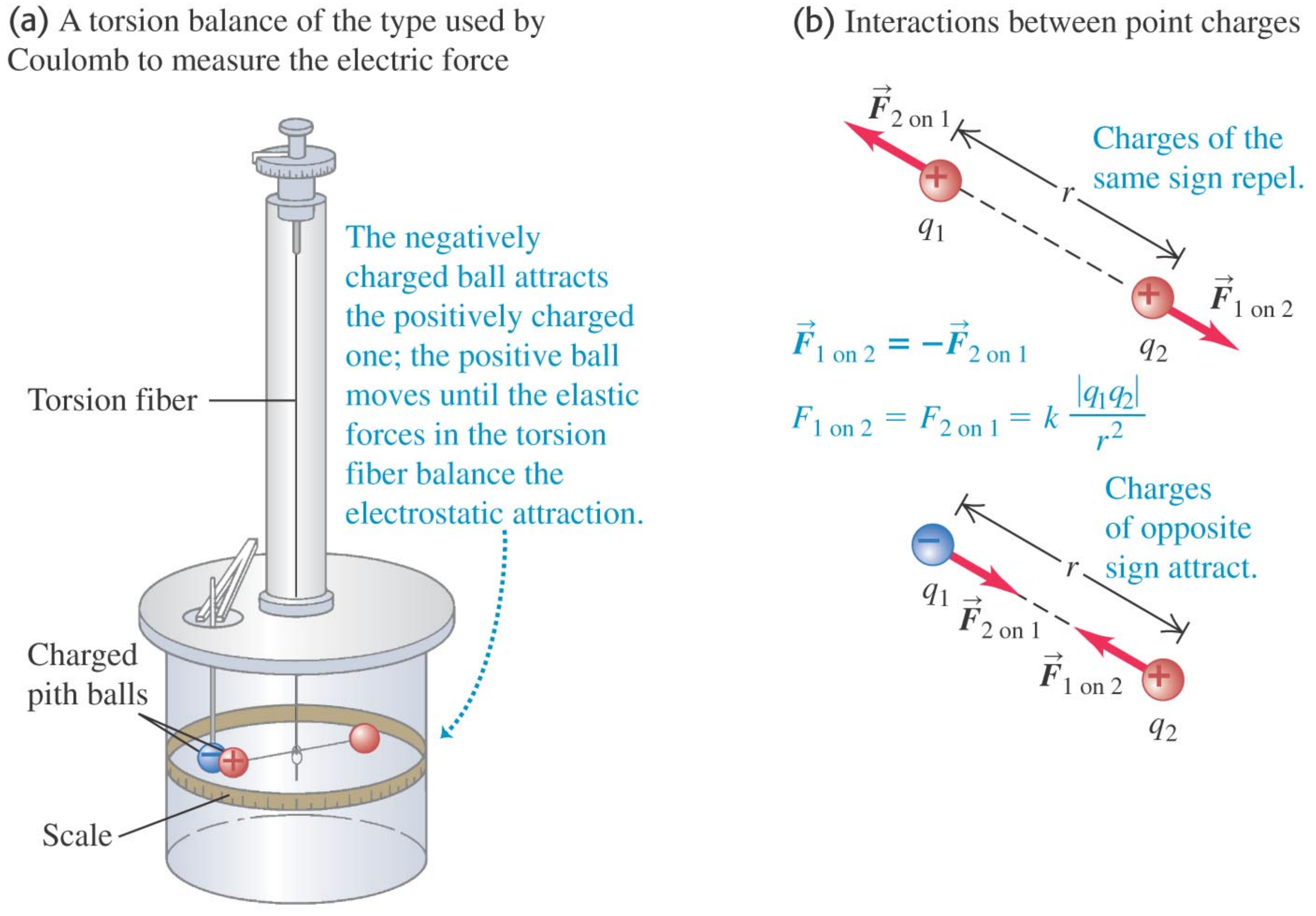
Charges will "seek" motion to ground

- An uncharged conductor can attract the charge imparted to paint droplets.



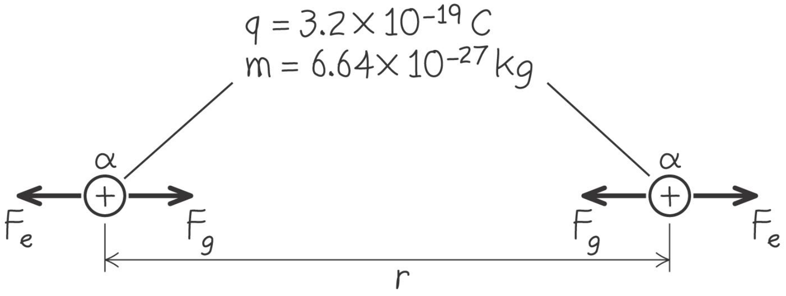
Charles Coulomb determined the electrostatic force law

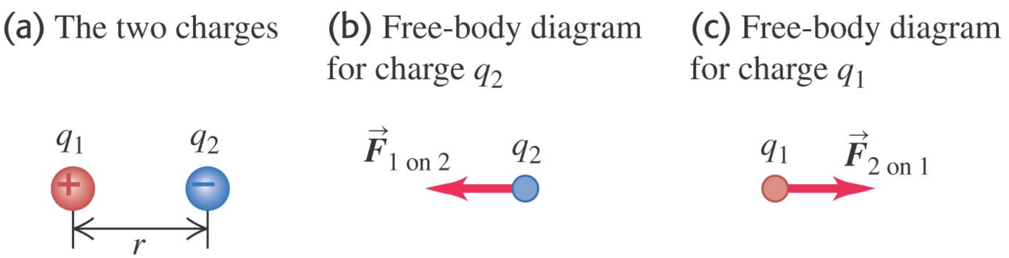
- *Coulomb's Law allows the calculation of electrostatic attraction or repulsion.*



Examples of electrical force calculated—I

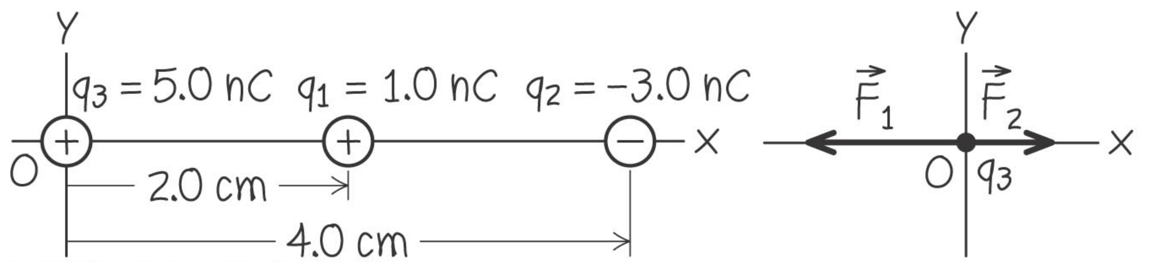
– A fascinating comparison of gravitational force to electrostatic force is shown in Example 21.1 and Figure 21.11.
– Regard Problem-Solving Strategy 21.1.
– See also Example 21.2 and Figure 21.12.

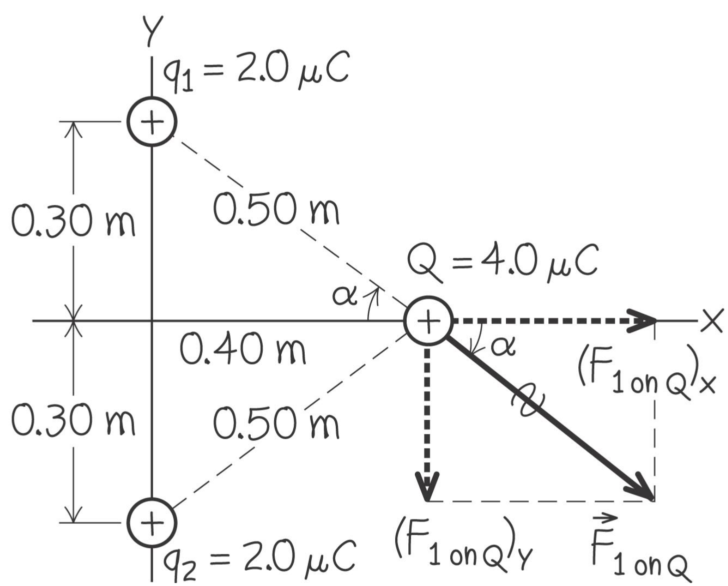




Examples of electrical force calculated—II

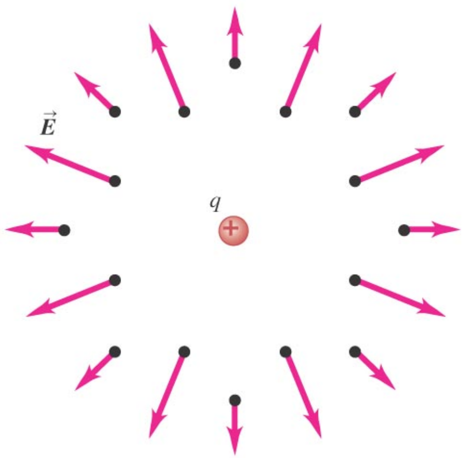
(a) Our diagram of the situation (b) Free-body diagram for q_3



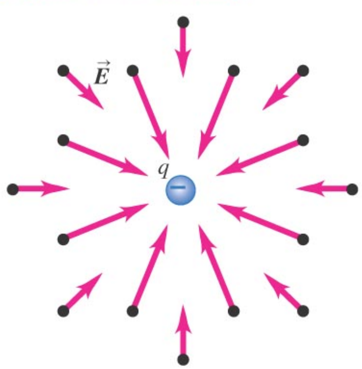


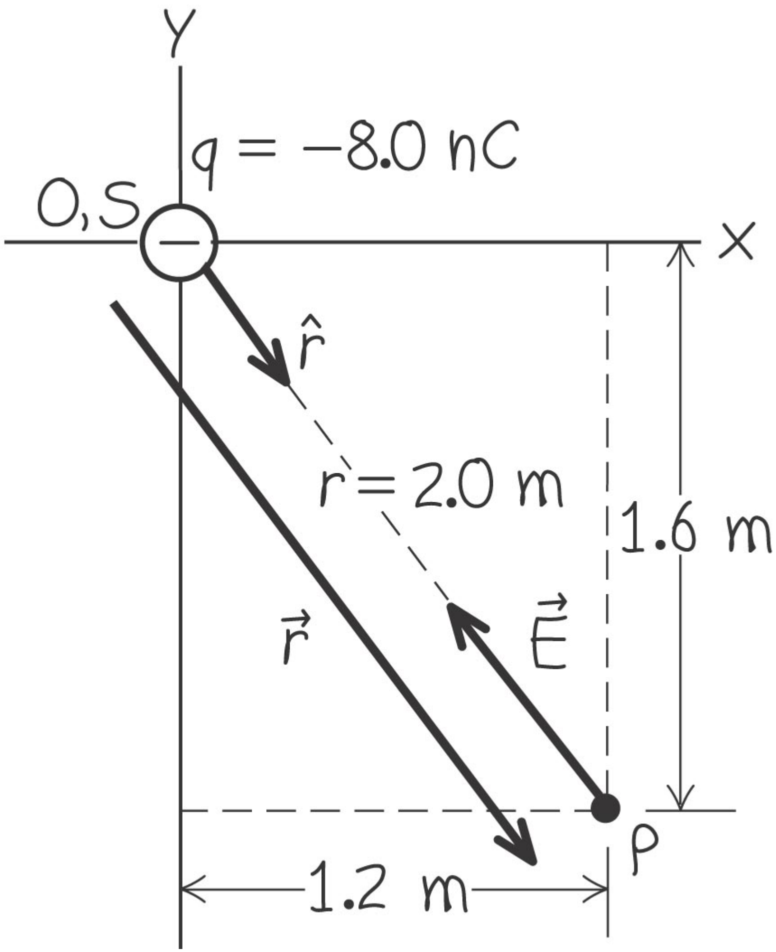
Electric fields I—the point charge

(a) The field produced by a positive point charge points *away from* the charge.

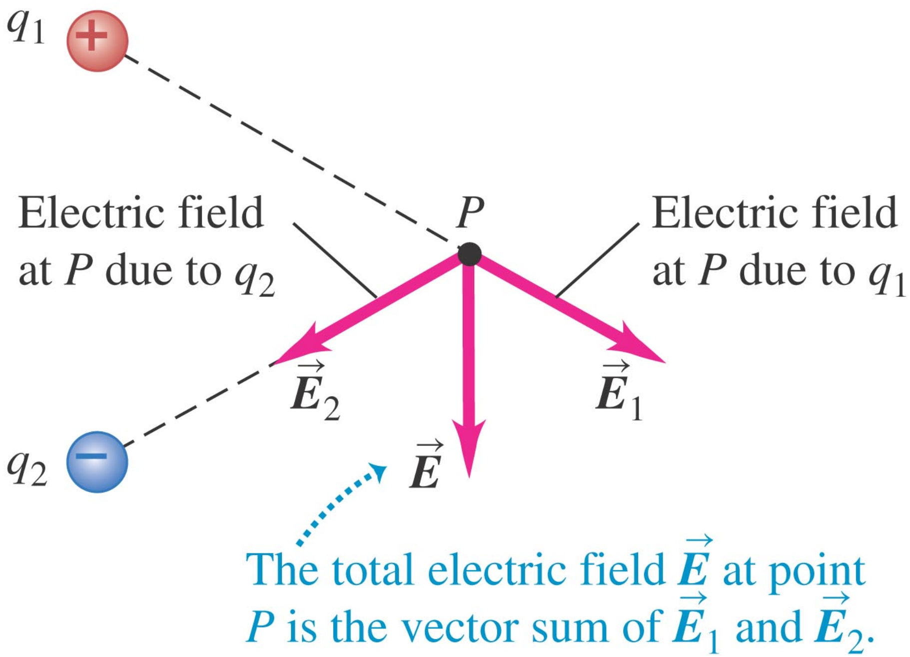


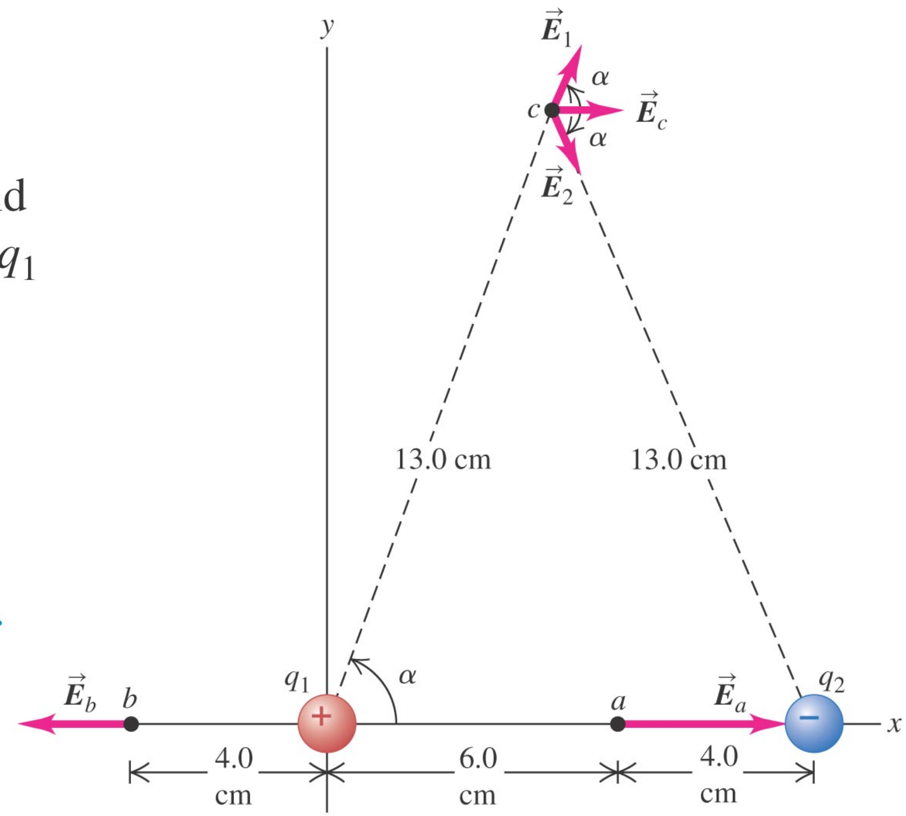
(b) The field produced by a negative point charge points *toward* the charge.



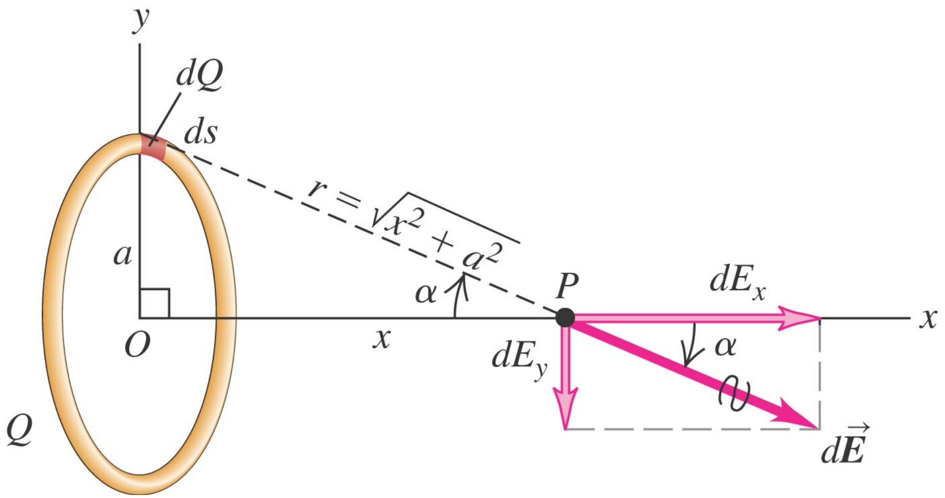


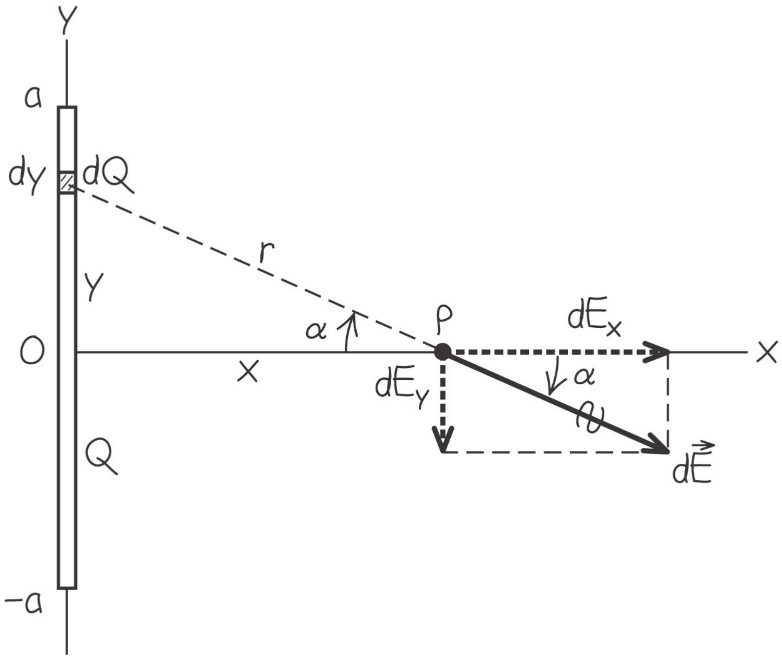
Electric fields add as vectors



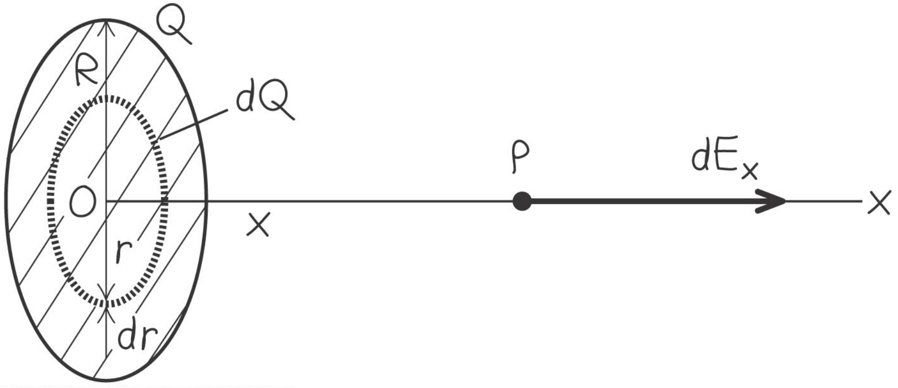


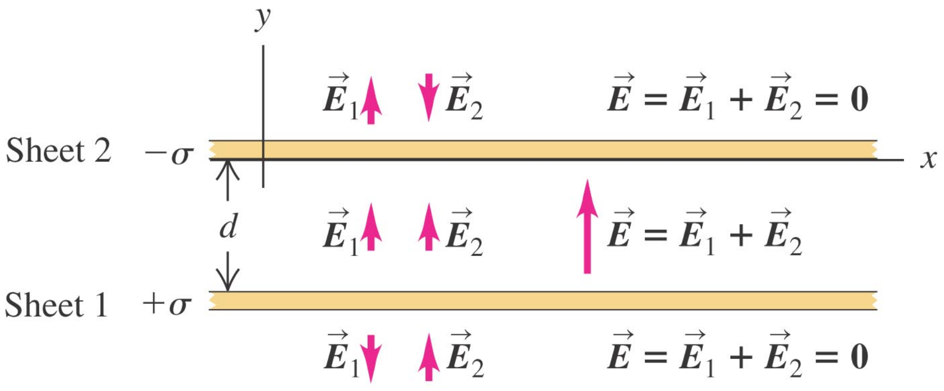
A field around a ring or line of charge



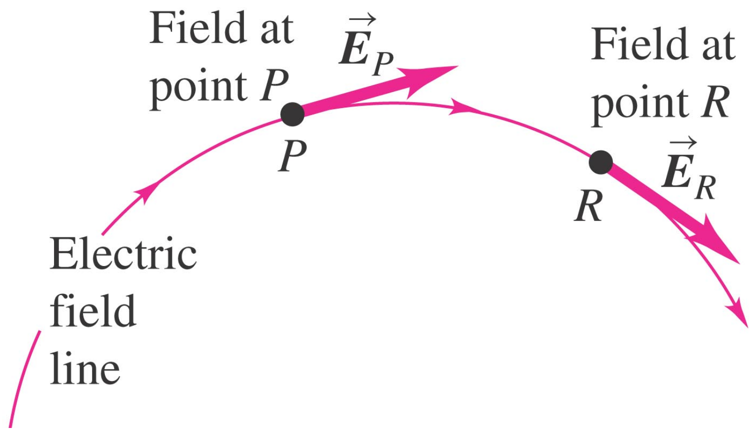


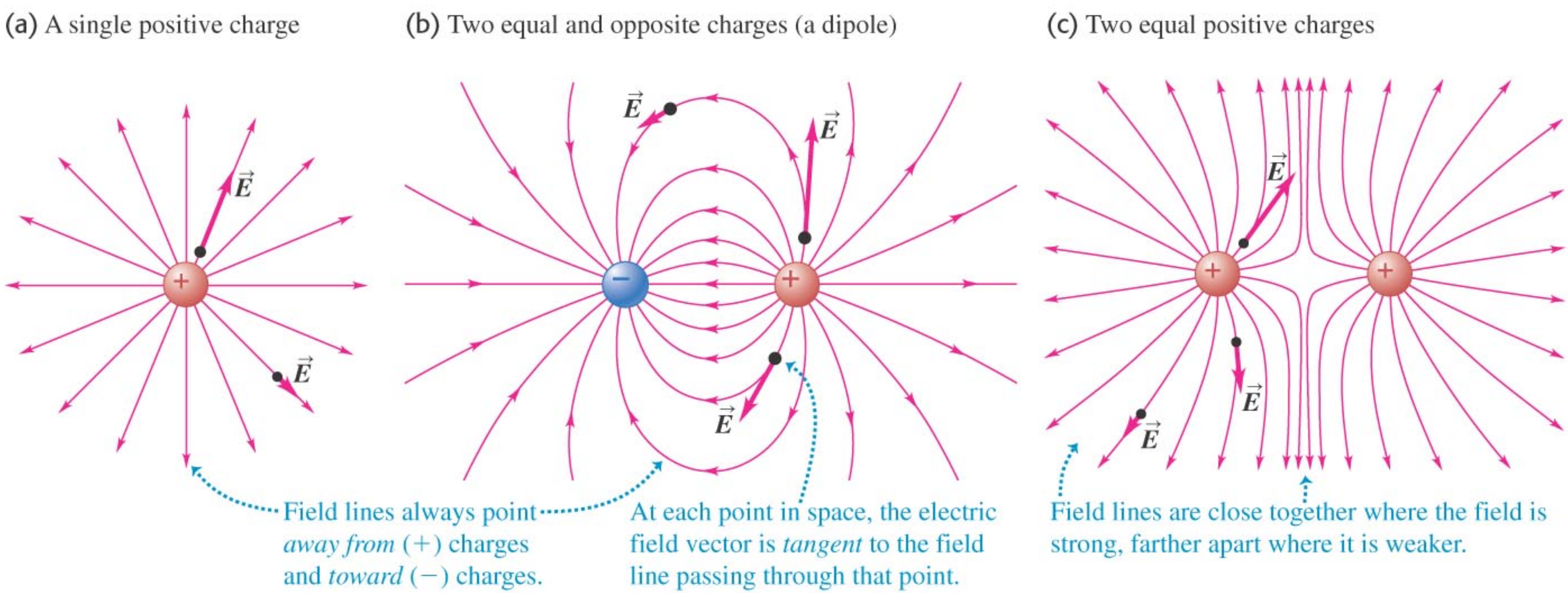
A field around a disk or sheet of charge





Electric field lines map out regions of equivalent force I

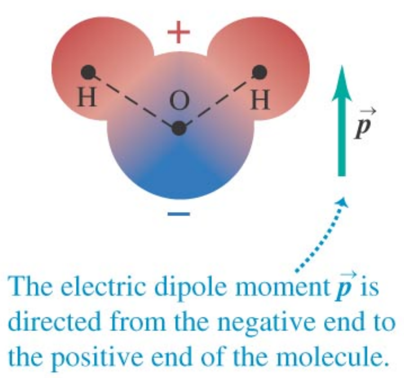




Electric dipoles and water

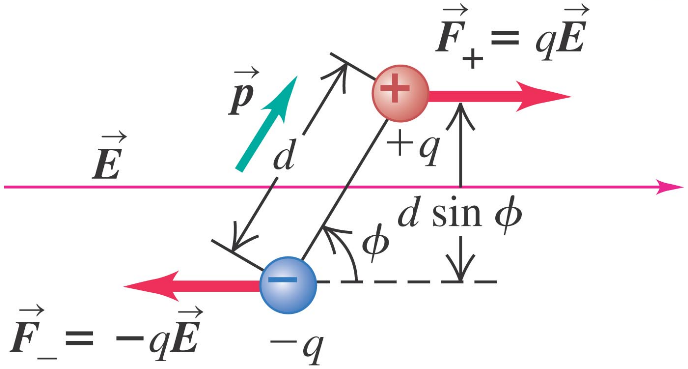
As mentioned in the introduction, the dipole force of water is vital to chemistry and biology.

(a) A water molecule, showing positive charge as red and negative charge as blue

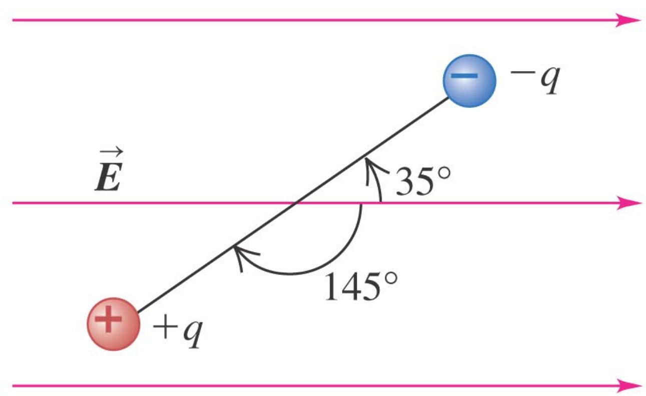


(b) Various substances dissolved in water

Force and torque on a dipole



(a)



(b)