

① Phys 1402 2014-09-02 Lec 2

Charged Objects

- Typically, $q=0$ because there are equal \oplus & \ominus charges
- Charge is given by adding or removing electrons (e^-)

$$q = Ne q_e$$

$$q_e = -1.6 \times 10^{-19} \text{ C}$$

Ex: $q = 64 \text{ nC}$

How many electrons?

$$64 \text{ nC} = N (1.6 \times 10^{-19} \text{ C})$$

$$N = \frac{64 \times 10^{-9} \text{ C}}{1.6 \times 10^{-19} \text{ C}} = 4 \times 10^{11}$$

Electric Fields caused by source charges

- Directional - point "downhill" on V landscape.
(V : elec potential)

- E-Field points away from \oplus
toward \ominus

(2)

Strength of E-Field

- Measured in newtons per coulomb (N/C)
- Also measured in volts per meter (V/m)
(i.e. E is slope of V)

- Point Charge: q all at same location

$$E = \frac{kq}{r^2}$$

$$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$$

= Coulomb constant

r = our distance from q.

- small r \rightarrow Large E
- large r \rightarrow Small E

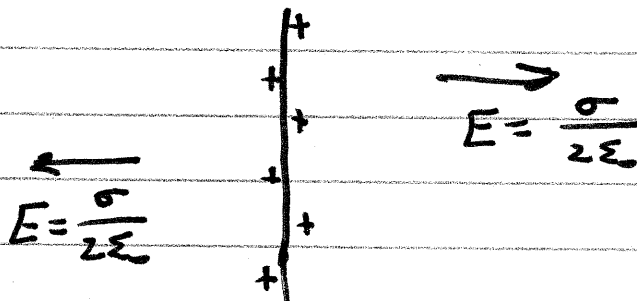
- Surface Charge: q spread out on a surface.
Typically measure charge density.

$$\sigma = \frac{q}{A} = \text{charge per unit area}$$

$$E = \frac{\sigma}{2\epsilon_0}$$

$$\epsilon_0 = \frac{1}{4\pi k} = 8.85 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}$$

Uniform Electric Field



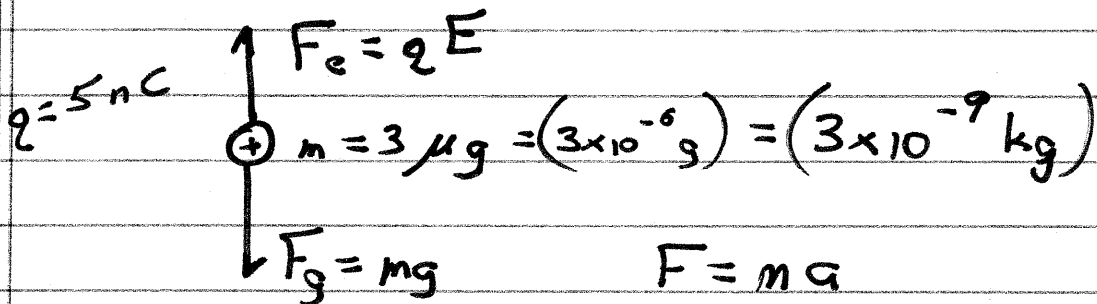
③

What does E do?

- Causes forces on charges

IF $E > 10^6 \text{ V/m}$, air is torn apart.
This makes sparks or lightning.

Ex: Levitating a styrofoam ball.



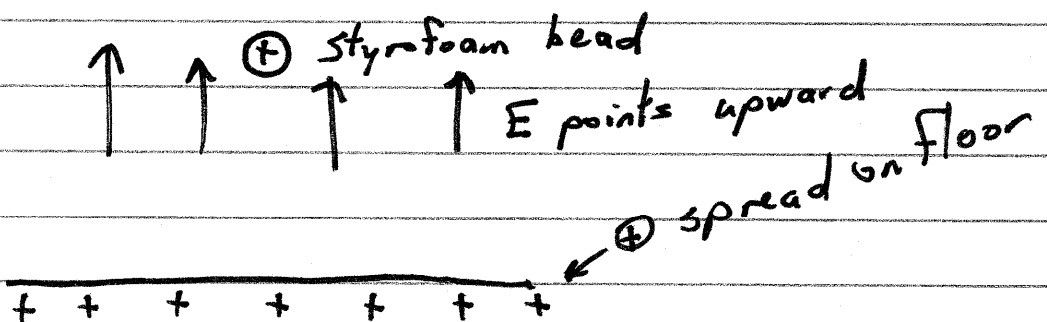
$$qE - mg = 0$$

$$qE = mg$$

$$E = \frac{mg}{q}$$

$$E = \frac{(3 \times 10^{-9} \text{ kg})(9.8 \text{ N/kg})}{5 \times 10^{-9} \text{ C}} = 5.88 \text{ N/C}$$
$$= 5.88 \text{ V/m}$$

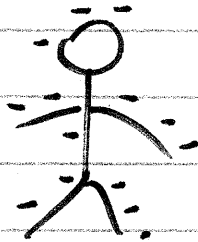
IF q is \oplus , what dir is E to levitate?
How? Maybe with a \oplus surface charge.



4

Why does static electricity make our hair stand on end?

- Our body has accumulated extra charge.
- We are a conductive material, so, charges move around freely.



- When on hair, the charges still repel.

Coulomb's Law

⊕

$q_1 = \text{source}$

$$E = kq_1/r^2$$

⊕ → F_E

$q_0 = \text{test charge}$

$$F_E = q_0 E$$

Combined: $F = k \frac{q_1 q_2}{r^2}$

$q_1 = 5 \text{ nC}$

$q_2 = 7 \text{ nC}$

$r = 5 \text{ cm}$

$$F = \frac{(9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2})(5 \times 10^{-9} \text{ C})(7 \times 10^{-9} \text{ C})}{(0.05 \text{ m})^2}$$

$$= 1.26 \times 10^{-4} \text{ N}$$

$$= 126 \mu\text{N}$$