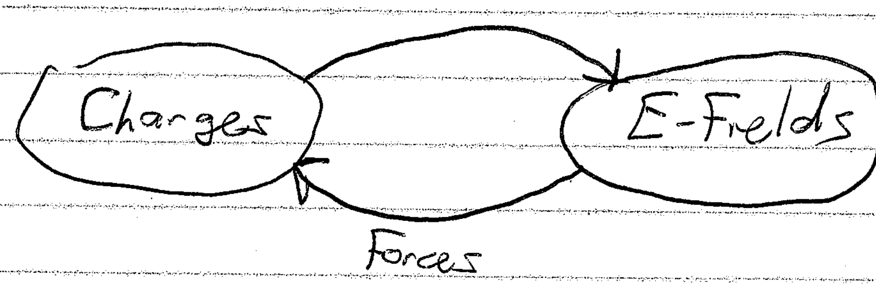
Phys 1402 2017-07-~~06~~ 05



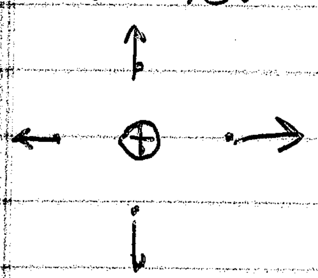
$\vec{F}_E = q\vec{E}$ q = charge "feeling" E or "test charge"

Calculating E-fields If $q = \oplus$, $\vec{E} \parallel \vec{F}_E$ same di

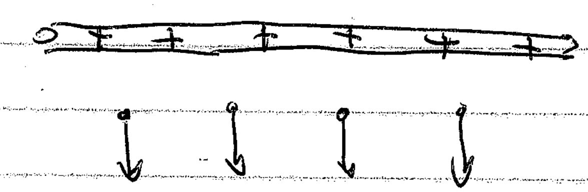
Point Charges: $E = \dfrac{kQ}{r^2}$

Line Charges: $E = \dfrac{2k\lambda}{r}$ λ = charge per Length

End View



Side View



Units: $\dfrac{Q}{r^2}$ in C/m^2 $\dfrac{\lambda}{r} = \dfrac{C/m}{m} = C/m^2$

Reminder: SMTE-0095 Due Sunday Night!

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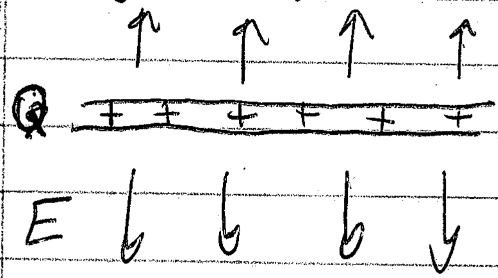
Surface Charge

Edge View



$E = 2\pi k \sigma$

$\sigma = \frac{\text{charge pe}}{\text{area}}$

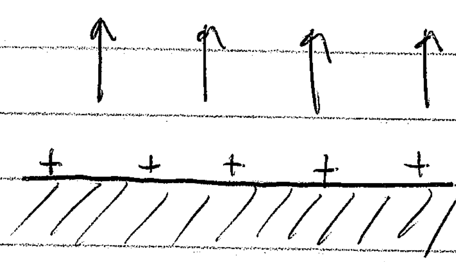
Note: doesn't depend on distance

Same E everywhere: Uniform $\vec{E}$

This was the <u>contribution</u> of a single surface.

- Thin surface or sheet

If we are looking at the <u>edge</u> of a block:



$E = 4\pi k \sigma$

$E = 0$ "inside"

This was the <u>actual total E</u> outside the metal surface.

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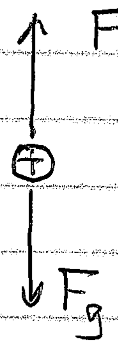
Consider a 1.68 mg styrofoam ball with a charge of +0.171 nC.

• What $\vec{E}$ will levitate it?



Need $F_E = F_g = mg = (1.68 \times 10^{-6}\ kg)(9.8\ N/kg)$

Note: $1\ mg = 10^{-3}\ g = 10^{-6}\ kg$

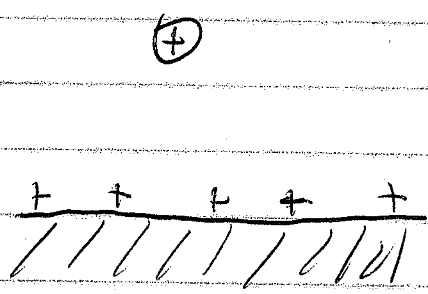
$F_g = 1.65 \times 10^{-5}\ N$

$$F_E = qE \longrightarrow E = \frac{F_E}{q} = \frac{1.65 \times 10^{-5}\ N}{0.171 \times 10^{-9}\ C}$$

└ nano $= 10^{-9}$

$$E = 96500\ N/C$$

Need E pointing up, so place $+\sigma$ below.



Ex: Charge a metal plate.

$$E = 4\pi k \sigma$$

$$\sigma = \frac{E}{4\pi k} = \frac{96500\ N/C}{4\pi (9 \times 10^{9}\ Nm^2/C^2)}$$

$$= 8.53 \times 10^{-7}\ C/m^2$$

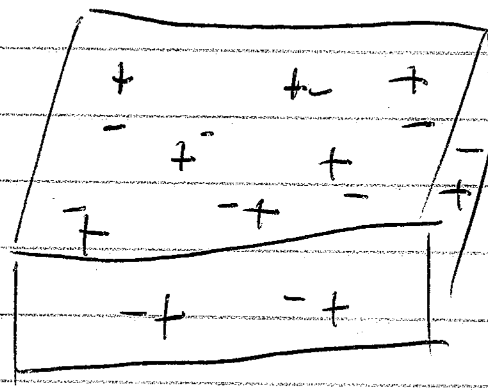
$$= 853\ nC/m^2$$

Conductors & Insulators

<u>Any object</u>

- Same number of p^+ and e^-.

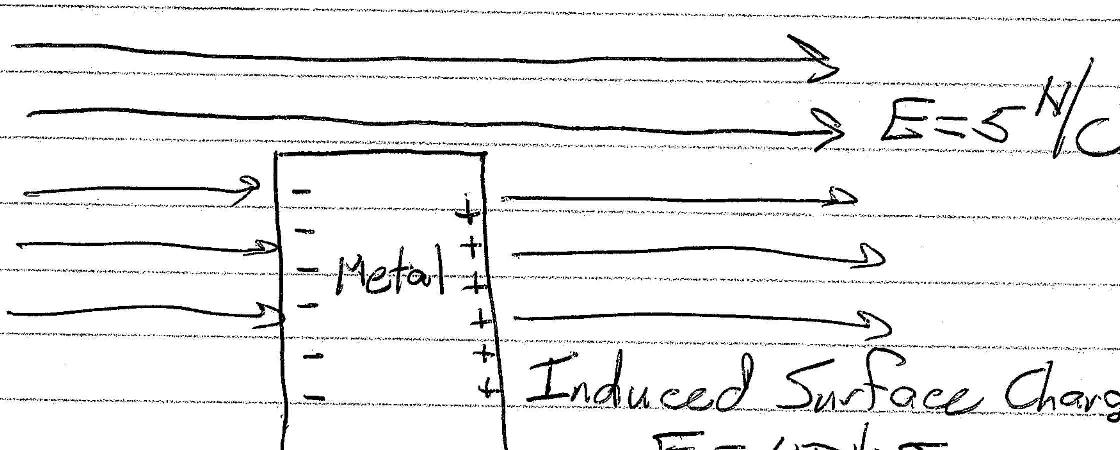
protons electrons



<u>Insulators</u>: All charges basically locked in place.

<u>Conductors</u>: Some $\ominus$ are mobile.

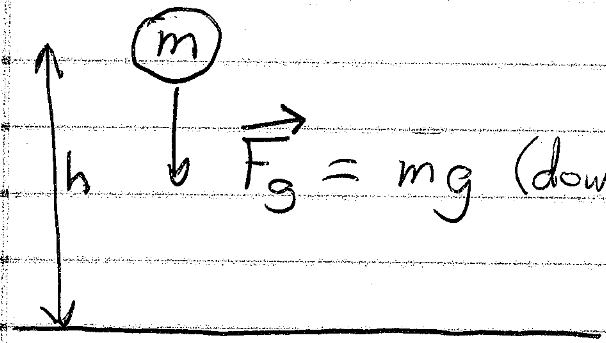
If we tried to have $E \neq 0$,
Then the mobile e^- would be pushed around.
It is possible to have everything <u>stop</u>.
Can't stop with $F_{net} \neq 0$.
It's actually not possible to have $E \neq 0$ inside.



Induced Surface Charge
$E = 4\pi k \sigma$

Recall Gravity Force vs Potential Energy

$$PE_g = mgh$$

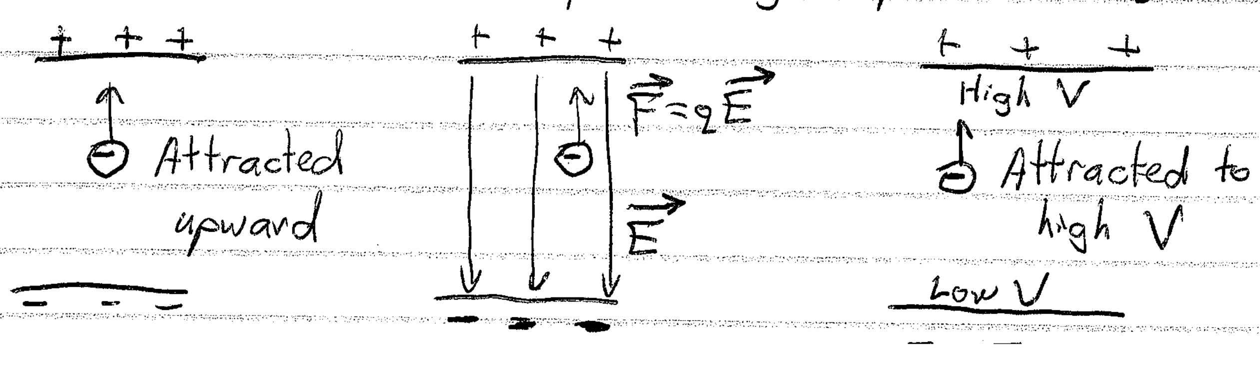


If you "Let go", the Force (F_g) moves it toward Lower potential energy (PE_g).

- Objects "seek out" Lower PE_g.
- F_g points "downhill".

The electric potential (V) is like PE_g but it is related to E instead of F_g.

- E points "downhill" toward lower V.
- ⊕ charges "seek out" lower (or more negative) potential (V).
- ⊖ charges "float up" to higher (positive) V.



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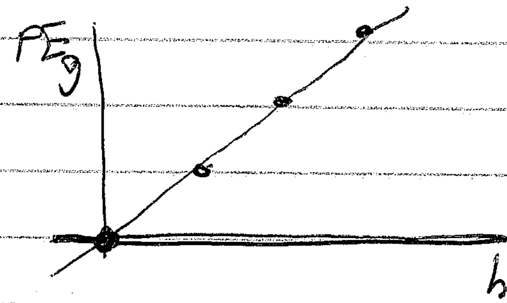
$\vec{F}_E = q\vec{E}$

- Force is slope of PE
- E is slope of V

$F_g = mg$ (down)

$PE_g = mgh$



Slope is:

$$\frac{\Delta PE}{\Delta h} = \frac{mgh_2 - mgh_1}{h_2 - h_1}$$

$$= \frac{mg(h_2 - h_1)}{h_2 - h_1}$$

$$= mg = |F_g|$$

Electric Potential Energy

$PE_E = qV$

Ex: Accelerate electron with 500 V.

$$\Delta PE = q\Delta V$$
$$= (1.6\times10^{-19}\,C)(500\,V)$$
$$= 8\times10^{-17}\,J$$

How fast is it going?

$KE = \frac{1}{2}mv^2 \longrightarrow v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{(2)(8\times10^{-17})}{9.11\times10^{-31}}}$

speed

$= 1.3\times10^{7}\ m/s$