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Lec 6. Selected problems in **15.2-15.8** **iq04**

1. Conductor:
    a. Ionized solutions. Mobile +/- ions. Mobile electrons.
    b. Apply external E to a conducting medium
        1. Initial stage: Drude model, drift velocity \propto Eext.
        2. Intermediate stage: drift velocity \propto (Eext – Epol) . Eventually Enet=0.
2. A metal block + two point charges (clicker **7-4**, see also clicker **7-3**)

    Typo:**7-4D**: Direction of the field at A (not at B)
3. Definitions: permanent dipole (e.g. water) vs induced dipole (e.g. Carbon tetrachloride) See **h1-015**.

    Digression: Write F \propto (1/r^n), where r is large. What is the n-dependence for cases below?
    a. Forces between q + permanent dipole
    b. Forces between q+ atom (induced dipole): clicker **6.2**
    c. Forces between two permanent dipoles (see p618, Fig. 15.70, clicker **5-3**)
    d. Force between a permanent dipole + atom (induced dipole). **What is n for this case**?
4. Clicker **8-1** (Discussion related to **h3-11**): Effect on the measured field when the magnitude of the test charge is non-negligible.
5. Discussion on **h3-16**. (see p605, **E=0 and q=(Q/8)(L/r)^2**)

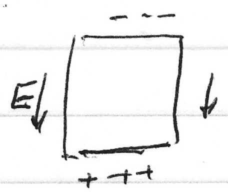
    Model estimate on the polarizability of a neutral atom: clicker **8-2**.

Class Announcements:
My regular office hour is MWF: 9:15-10:15. Other time by appointment.

8.04 Lec 6-1

E interaction matter { Insulator
Conductor { Ionized Solution
Metal

Mobile electrons



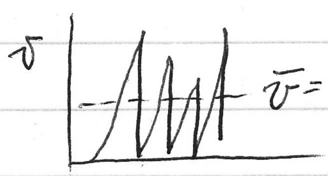
Initial stage

$F = qE = ma$

$a = \frac{qE}{m}$

Drift velocity: $v = a\Delta t = \frac{qE}{m}\Delta t$ Initial

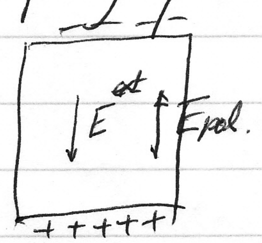
Collision: Δt



$\bar{v} = a\Delta t$ (collision time)

$\bar{v} = \left(\frac{q\Delta t}{m}\right)E = uE$ (mobility)

Macroscopic charge separation -



$\bar{v} = \left(\frac{q\Delta t}{m}\right)\left(E^{ext} - E_{pol}\right)$ Intermediate

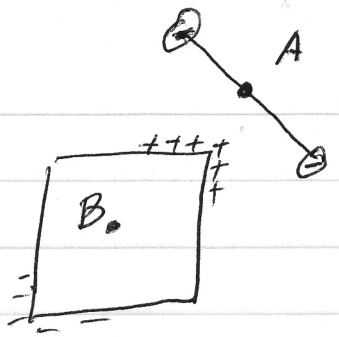
Eventually: $\bar{v} = 0$, $E_{net} = 0$.

Static equilibrium.

⇒ checker 7-3: What is net field at B? Ans = 0

E_B': due to surface charge ↑

E_B'': due to external ↓



A: E at B due to due to positive surface charge

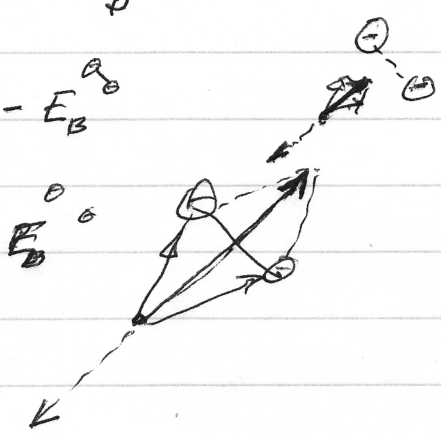
B: E at B due to <u>all</u> charges —
Resultant field at B 0

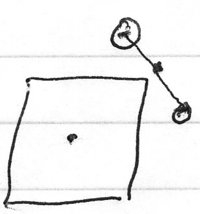
C. E at B due to all surface charges.

at B: $E^+ + E^- + E_B^{\ominus\ominus} = 0$

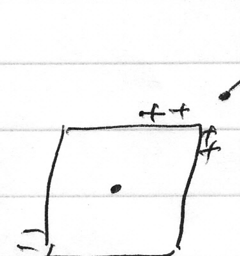
$E_B^+ + E_B^- = -E_B^{\ominus\ominus}$

Work Hint: What is: $E_B^{\ominus\ominus}$
lent



D. 

E_A due to all charges,
due to surface charge



Digression on [h1-015]

~~Permanent dipole : Water   Induced dipole~~

Water : Permanent dipole

Carbontetrachloride : No perm dipole

There is induced dipole.

Skip

q_1 — q_2 $\frac{k q_1 q_2}{r^2}$

q p $\left(q\frac{2kp}{r^3}\right)$

q atom (p_1) $q\frac{2kp_1}{r^3}$ $p_1 = \alpha E_r^q = \left(\alpha \frac{kq}{r^2}\right)$

↓

$q\frac{2k}{r^3}\ \frac{\alpha k q}{r^2}$ $\propto \frac{1}{r^5}$

p-p : Look earlier exercise

$-q$ $+q$ —— p

$$\frac{2kpq}{r^3}\left[\frac{1}{(1-\epsilon)^2} - \frac{1}{(1+\epsilon)^2}\right]$$

$4\epsilon = 4\left(\frac{s}{2r}\right) = \frac{2s}{r}$

$\frac{1}{r^4}$

$p = qs$ p–atom   What is n in $F \sim \frac{1}{r^n}$?

$-q$ $+q$ —— r —— p' $p' = \alpha E^p_{atom} = \left(\alpha \frac{2kp}{r^3}\right)$ ✓

$$F = q\frac{2kp'}{r^3}\left[\frac{1}{(1-\epsilon)^3} - \frac{1}{(1+\epsilon)^3}\right]$$

$= 6\epsilon = 6 \cdot \frac{s}{2r} = \frac{3s}{r}$

What is n in $\frac{1}{r^n}$

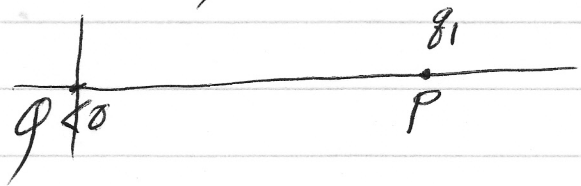
n :

A	6
B	7
C	8

Discussion on [63-11]

Definition: $\mathbf{E} = \lim_{q \to 0} \frac{F}{q}$

Example: Let $Q<0$



Generalization / Explanation

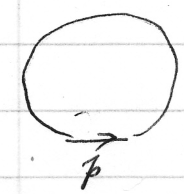
Sketch For a conducting sphere with charge Q on it,

place pos q_1 at P get F_1

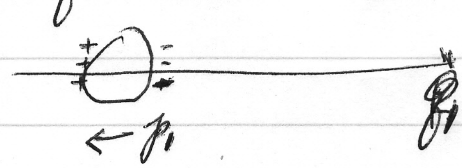
pos q_2 at P at F_2

If $q_2 > q_1$ shows $\frac{F_2}{q_2} = E_2 > \frac{F_1}{q_1} = E_1$

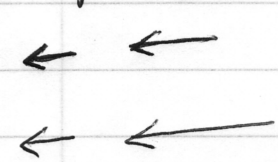
$E_2 > E_1$

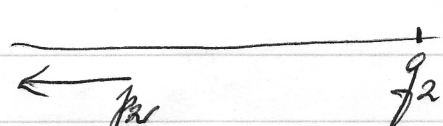


Reasoning: q_1 leads to $E_0^{q_1} \Rightarrow p_1$



$E_p' = E_p^Q + E_p^{p_1}$

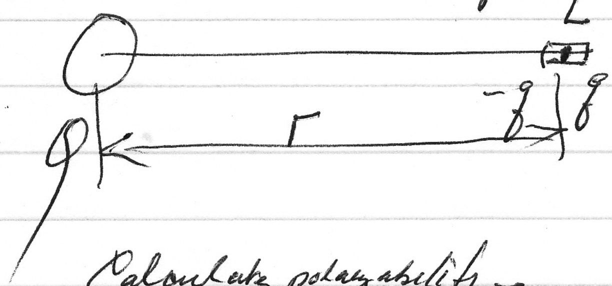




$\therefore E_p'' > E_p'$

HW 3-16 Polarizability Read: Phys Assume $E_0^{dipole} + E_0^{Q} = 0$

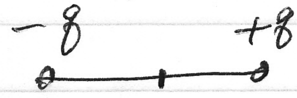
Hint calc of α Only known



Calculate polarizability

$$p = \alpha E_0^{Q}$$

Equil. condition: At O $E_0^{dipole} + E_0^{Q} = 0$



$$E_0^{dipole} = E_0^{-q} + E_0^{+q} = \frac{2kq}{\left(\frac{L}{2}\right)^2}$$

$$\frac{kq}{\left(\frac{L}{2}\right)^2} \qquad \frac{kq}{\left(\frac{L}{2}\right)^2}$$

$\leftarrow \qquad \leftarrow$