Methods developed for finding $\vec{E}$ in vacuum can also help with linear dielect

Note: if $\rho_f = 0$ then $\rho_B = 0 \Rightarrow$ Laplace

σ_B at boundary $\Rightarrow$ use BC

ϕ continuous

$\Delta D_n = \sigma_f$

Eg: dielectric sphere in uniform $\vec{E} = E_0 \hat{k}$

$$\phi_{in} = \sum A_n r^n P_n \qquad (r \to 0 \Rightarrow C_n = 0)$$

$$\phi_{out} = -E_0 r P_1 + \sum \frac{C_n}{r^{n+1}} P_n \qquad (r \to \infty \Rightarrow \text{most } A_n = 0)$$

$$\phi_{in}\Big|_{r=R} = \phi_{out}\Big|_{r=R} \Rightarrow$$ coef P_n match

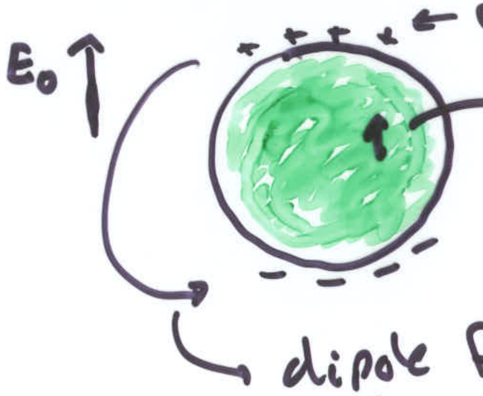
eg $A_1 R^1 = -E_0 R + \frac{C_1}{R^2}$

$$\Delta D_n = 0 \Rightarrow \kappa \partial_r \phi_{in}\Big|_{r=R} = \partial_r \phi_{out}\Big|_{r=R}$$

eg $\kappa A_1 = -E_0 - \frac{2C_1}{R^3}$

"homogeneous linear equs have trivial solution"

$\Rightarrow A_n = C_n = 0$ for $n > 1$



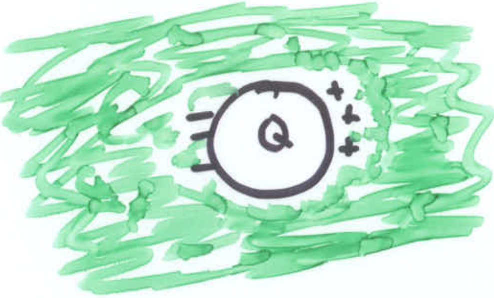
E reduced to $\frac{3E_0}{\kappa + 2}$

E inside

dipole field from C_1

$$P = \frac{\frac{4}{3}\pi R^3 \chi \epsilon_0 E_0}{(\kappa+2)/3}$$

Force on a charged conductor in dielectric



$$\phi_{out} = \left(-E_0 r + \frac{E_0 R^3}{r^2}\right) P_1 + \frac{Q}{4\pi\varepsilon r}$$

not ε_0

ϕ_{in} = constant

Find σ_f on surface $= D_n = \varepsilon E_r$

$$\vec{F} = \frac{1}{2} \int \vec{E}\, \sigma_f(\theta)\, R^2 \sin\theta\, d\theta\, d\phi$$

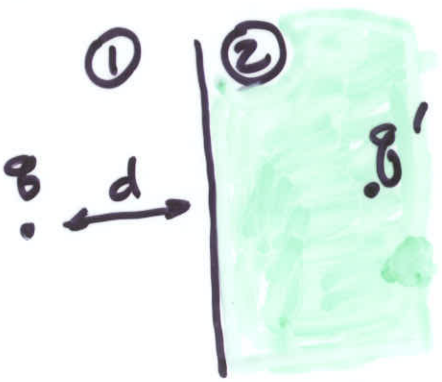
only $E_r \neq 0$; $E_z = E_r \cos\theta$

(clear E_x & $E_y = 0$?)

average?

self-force subtraction

real charge on lhs of boundary two dielectrics



use above when in region ①

use above when in region ②

at every point on boundary require:

$\phi^{①} = \phi^{②}$; $\varepsilon_1 E_x^{①} = \varepsilon_2 E_x^{②}$

$$q' = \frac{K_1 - K_2}{K_1 + K_2} q \qquad q'' = \frac{2K_2}{K_1 + K_2} q$$

$$\phi_1 = \frac{1}{4\pi\varepsilon_1}\left(\frac{q}{r} + \frac{q'}{r'}\right) \qquad \phi_2 = \frac{1}{4\pi\varepsilon_2} \frac{q''}{r''}$$

esu
emu

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = \frac{q_1 q_2}{r^2}$$

cgs

gaussian → SI

Chapter 5 → physics

$\uparrow P \quad \downarrow E \quad \frac{P}{3\varepsilon_0}$

molecule sees

$$E_m = E - E + \sum E$$

macroscopic E

from polarized sphere

due to nearby atoms

= 0

$$= E + \frac{P}{3\varepsilon_0} + \sum_{\text{atoms nearby}} E_i$$

atom random

$E = 0$

$$\vec{E} = \frac{1}{4\pi\varepsilon_0}\left[\frac{3(\hat{r}\cdot\vec{p})\hat{r} - \vec{p}}{r^3}\right]$$

single dipole

$\downarrow p$

$\uparrow 2p$

$2p \times 4p$

cubic $\Rightarrow 0$

solid $\rightarrow \sum E \neq 0$

$$E_m = E + \frac{P}{3\varepsilon_0}$$

$\vec{p} = \alpha \vec{E}$ $\# \frac{\text{atoms}}{m^3}$

$\vec{P} = \vec{p}\, N$ "number density"

$$P = \underbrace{p}_{\alpha E_m} N = \alpha N \left(E + \frac{P}{3\varepsilon_0}\right)$$

$$P = \chi \varepsilon_0 E$$

$$P\left(\frac{1}{\alpha N} - \frac{1}{3\varepsilon_0}\right) = E$$

$$P = \underbrace{\frac{1}{\left(\frac{1}{\alpha N} - \frac{1}{3\varepsilon_0}\right)}}_{\chi \varepsilon_0} E$$

$$\frac{1}{\frac{\varepsilon_0}{\alpha N} - \frac{1}{3}} = \chi$$

$$\frac{1}{\chi} = \frac{\varepsilon_0}{\alpha N} - \frac{1}{3}$$

$$\frac{1}{\chi} + \frac{1}{3} = \frac{\varepsilon_0}{\alpha N}$$

$$\alpha = \frac{\varepsilon_0}{N} \frac{1}{\left(\frac{1}{\chi} + \frac{1}{3}\right)} \qquad \chi = K - 1$$

$$= \frac{\varepsilon_0}{N}\left(\frac{3\chi}{3+\chi}\right)$$

$$= \frac{3\varepsilon_0}{N}\left(\frac{(K-1)}{K+2}\right)$$

$$\alpha \sim \chi \Leftarrow$$

e cloud: const density ρ

R

$Ze \leftarrow 1.6\times10^{-19}\,C$

E

E

$p = (Ze)\,x$

$$E\,4\pi r^2 = \frac{\rho \frac{4}{3}\pi r^3}{\varepsilon_0}$$

$$E = \frac{Q}{4\pi\varepsilon_0}\,\frac{r}{R^3}$$

$$x = E\,\frac{4\pi\varepsilon_0 R^3}{Q}$$

$Q \leftarrow Ze$

$$p = E\left(4\pi\varepsilon_0 R^3\right)$$

$$= E\,\varepsilon_0\left(\frac{4\pi}{3}R^3\right)3$$

Volume of atom

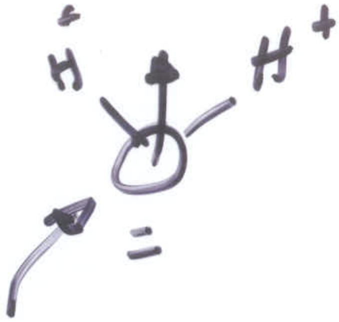
$$\alpha = \varepsilon_0\, 3V$$

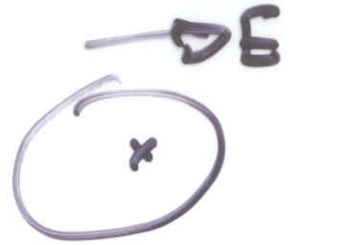
$$\alpha N = \varepsilon_0 \chi$$

$$\varepsilon_0\, 3VN$$

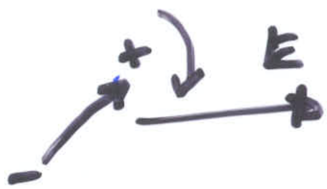
$$P = \underbrace{\alpha N}_{\varepsilon_0 \chi} E$$

$$\chi = 3V\,\frac{\#\text{atoms}}{\text{volume}}$$





$$PE = -\bar{p} \cdot E$$



✓

"High Temps destroy composites"

↳ KE

$$\Delta G = \Delta H - T\Delta S$$

Gibbs ← physicist

Maxwell

Kelvin

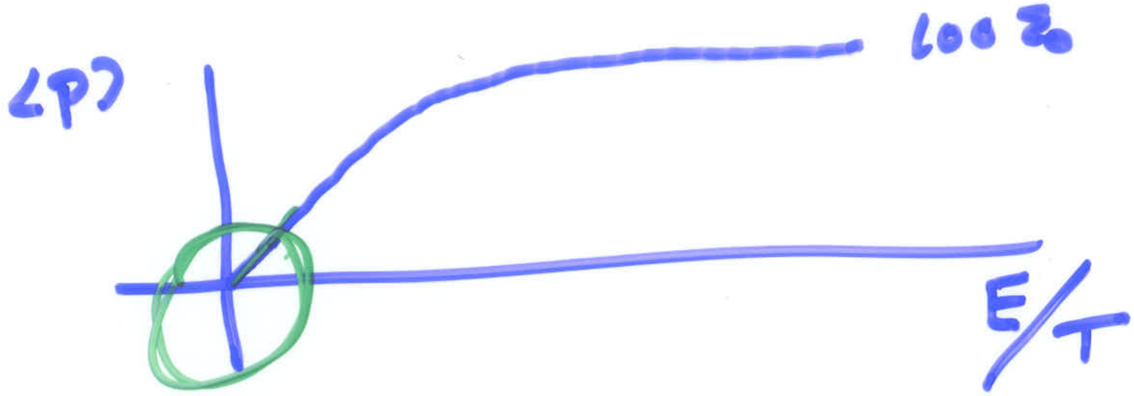
Boltzmann

enthalpy

$U + PV$

$$\text{Prob} \sim e^{-E^*/kT}$$

$$\langle P \rangle = \frac{\Sigma(\text{Prob})\, P}{\Sigma(\text{Prob})}$$



$$\frac{p_0^2}{3}\frac{E}{kT} \simeq \frac{p_0}{3}\left(\frac{p_0 E}{kT}\right)$$

PM -

Ferroelectric

hysteresis

P curie