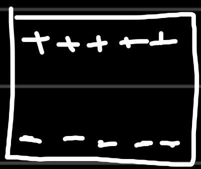
Lecture 24



dielectric : seperation of charges take place.

$P = Ned$ → polarisation

$\therefore P = \alpha E$ → polarizability

$P = \chi \varepsilon_0 E$ → susceptibility

{vulnerability of polarisation}

vacuum dielectric constant $\{\varepsilon = \varepsilon_r \varepsilon_0\}$

$\{\varepsilon_r = \varepsilon_r' + j\varepsilon_r''\}$

Reflection / Absorption / Refraction.

$$\tilde{n} = n + iK$$

By Fresnel's Law: $R = \left| \frac{\tilde{n} - 1}{\tilde{n} + 1} \right|^2$

$$\boxed{q = \frac{2\pi}{\lambda}}$$

$$\underset{\text{(free)}}{E} = E_0 e^{-i(q \cdot r - \omega t)}$$

$$\underset{\text{(medium)}}{E'} = E_0 e^{-i(q' r - \omega t)}$$

$$q' = q_0 \tilde{n}$$

→ connecting dielectric and refractive index

$$\boxed{\tilde{n}^2 = \varepsilon}$$

$$\varepsilon_r = \varepsilon_1 + j\varepsilon_2 \qquad \tilde{n} = n + iK$$

$$\varepsilon_1 = n^2 - K^2$$

$$\varepsilon_2 = 2nK = \frac{\sigma}{\varepsilon_0 \omega}$$

$$n^2 = \frac{1}{2}\left(\sqrt{\varepsilon_1^2+\varepsilon_2^2} + \varepsilon_1\right)$$

$$K^2 = \frac{1}{2}\left(\sqrt{\varepsilon_1^2+\varepsilon_2^2} - \varepsilon_1\right)$$

* At small frequencies, conductivity is also high $\varepsilon_2 >> \varepsilon_1$ i.e $\varepsilon_1 \to 0$

$\hookrightarrow$ $\boxed{n^2 = K^2}$

$\varepsilon = \varepsilon_1 + j\varepsilon_2$

ε_2 $\hookrightarrow$ related to losses

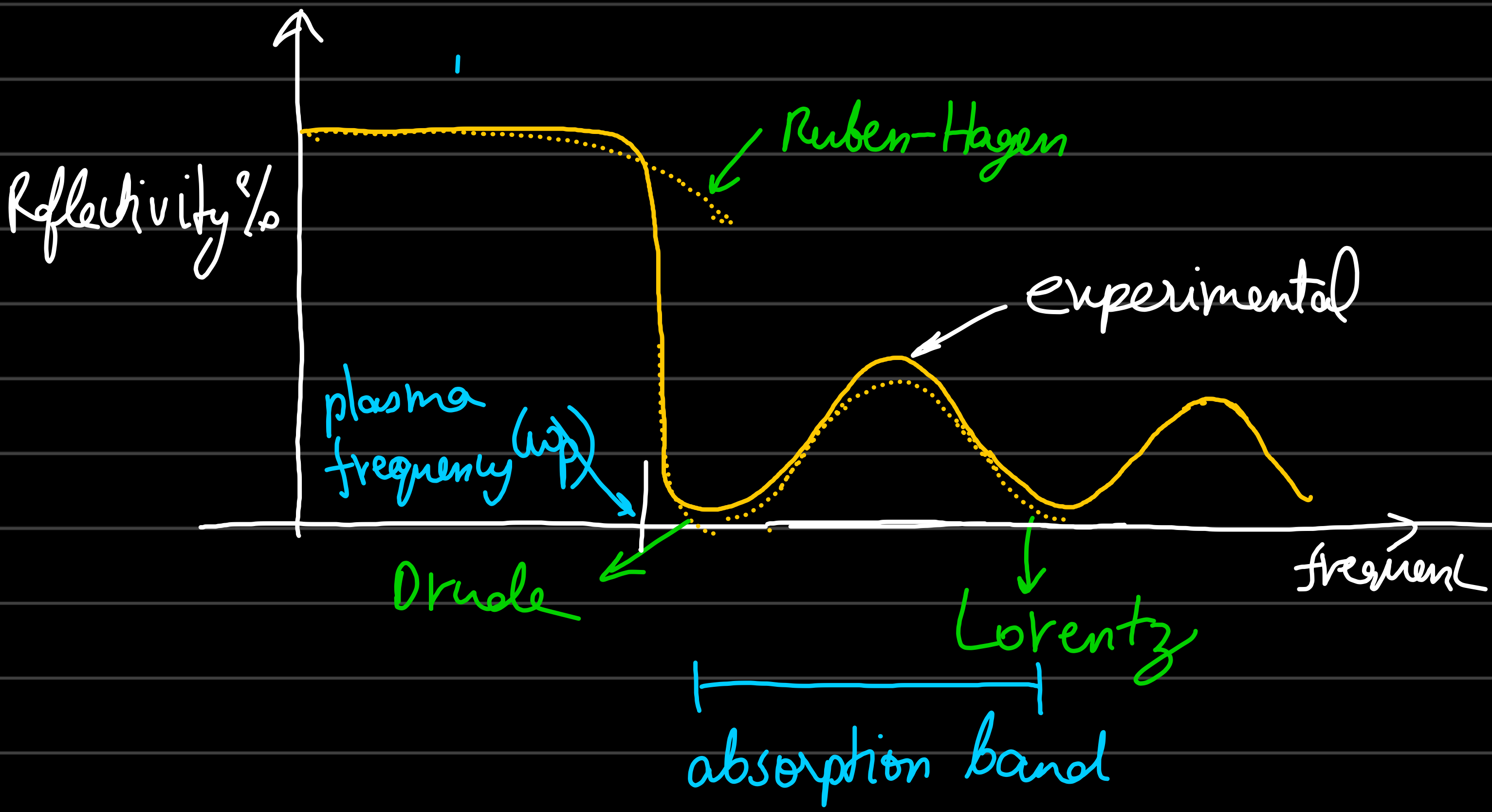
Loss tangent : $\tan\phi = \dfrac{\varepsilon_2}{\varepsilon_1}$

* Ruben-Hagen relation: $\boxed{R = 1 - \dfrac{2}{n}}$

Drude's conductivity: $\sigma(\omega) = \dfrac{\sigma_0}{1 - i\omega\tau}$

ω_p = plasma frequency

Lorentz Oscillators:



- Considering a spring mass system:

driving force: $F_d = E_0 \cos\omega t$

restoring spring force: $F_s = -kx$

A damping force: $F_d = \gamma m \frac{dx}{dt}$

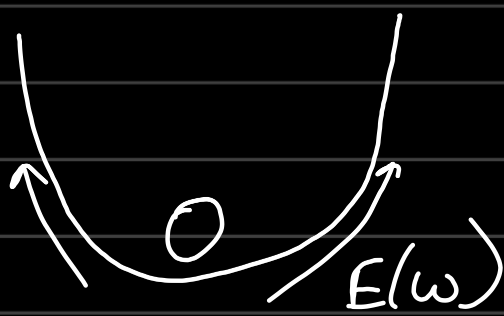
$$F = m\frac{d^2x}{dt^2}$$

Drawing electron cloud wave parallels.

$$\underline{\underline{x = x_0 e^{-i\omega t}}}$$

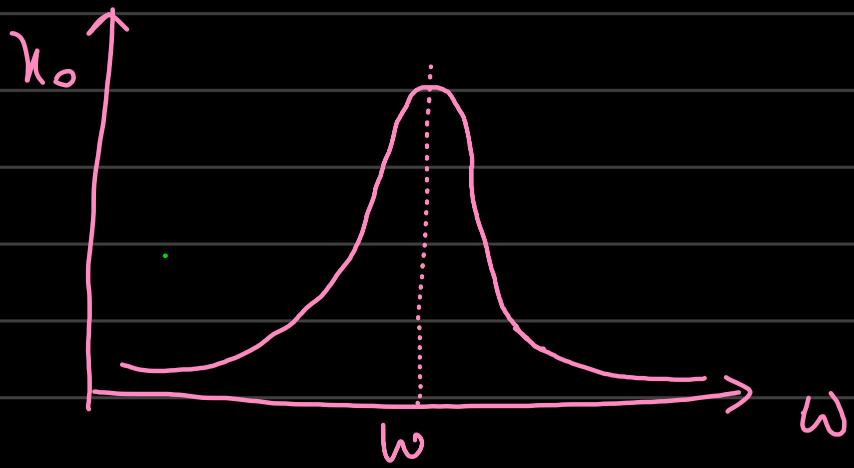
$\downarrow$

substituting in Newton force equation.



$$m\ddot{x} = qE_0\cos\omega t - kx - \gamma m\dot{x}$$

$$x_0 = \frac{eE_0}{m}\,\frac{1}{\omega_0^2 - \omega^2 - i\omega\gamma}$$



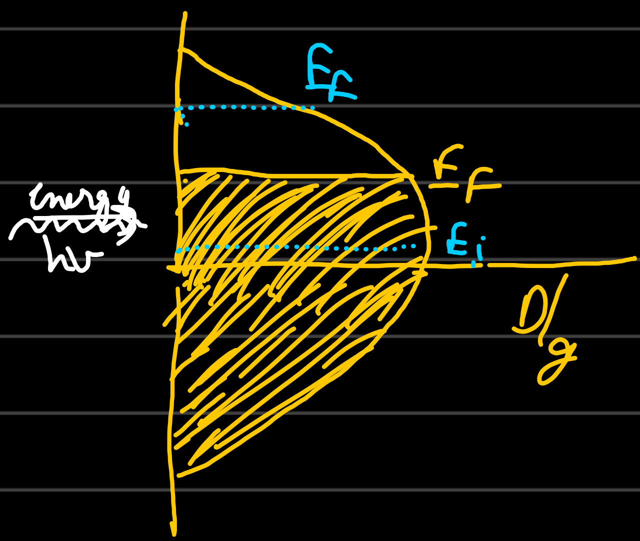
$$P = N x_0 q = \varepsilon_0 \chi E$$

$$\chi = \frac{N\;{}^{2}}{m\varepsilon_0}\left(\frac{1}{\omega_0^2 - \omega^2 - i\omega\gamma}\right)$$

$$\omega_p^2 = \frac{Ne^2}{m\varepsilon_0}$$

$$\left\{ \text{Lorentz function} = \frac{1}{(x^2+1)} \right\}$$

Quantum mechanical Treatment



i) energy conservation.

$$E_F - E_i = h\nu$$

$$\hbar k_f - \hbar k_i = \hbar c k_{ph}$$

$$P_f - P_i = P_{photon}$$

conservation of momentum.

→ Metals absorb radiation as empty states present above E_F

→ For semiconductor, a minimum energy equivalent to band gap for absorption.