

11. *Electricity and Magnetism* (Spring 2004)

Consider a plasma of free charges of mass m and charge e at constant density n . What is the index of refraction for electromagnetic waves of frequency ω which are incident upon this plasma?

$$v = \frac{c}{n_i} \Rightarrow \frac{1}{\sqrt{\mu\epsilon}} = \frac{1}{n_i \sqrt{\mu_0 \epsilon_0}} \Rightarrow n_i = \sqrt{\frac{\mu\epsilon}{\mu_0 \epsilon_0}}$$

Unless if a substance is ferromagnetic, its magnetic susceptibility μ will be approximately μ_0 , so $n_i \cong \sqrt{\frac{\epsilon}{\epsilon_0}}$

Recall $\frac{\epsilon(\omega)}{\epsilon_0} \cong 1 - \frac{\omega_p^2}{\omega^2}$ and $\omega_p^2 = \frac{ne^2}{\epsilon_0 m}$

$$\text{So } n_i(\omega) \cong \sqrt{\frac{\epsilon(\omega)}{\epsilon_0}} \cong \sqrt{1 - \frac{\omega_p^2}{\omega^2}} = \sqrt{1 - \frac{ne^2}{\epsilon_0 m \omega^2}}$$