

Problem 9.23 If you take the model in Ex. 4.1 at face value, what natural frequency do you get? Put in the actual numbers. Where, in the electromagnetic spectrum, does this lie, assuming the radius of the atom is 0.5 \AA ? ~~Find the coefficients of refraction and dispersion and compare them with those for hydrogen at 0°C and atmospheric pressure. $A = 1.36 \times 10^{-4}$, $B = 7.7 \times 10^{-15} \text{ m}^2$.~~

Problem 9.24 Find the width of the anomalous dispersion region for the case of a single resonance at frequency ω_0 . Assume $\gamma \ll \omega_0$. Show that the index of refraction assumes its maximum and minimum values at points where the absorption coefficient is at half-maximum.

Problem 9.27 Show that the mode TE_{00} cannot occur in a rectangular wave guide. [*Hint:* In this case $\omega/c = k$, so Eqs. 9.180 are indeterminate, and you must go back to 9.179. Show that B_z is a constant, and hence—applying Faraday’s law in integral form to a cross section—that $B_z = 0$, so this would be a TEM mode.]

Problem 9.28 Consider a rectangular wave guide with dimensions $2.28 \text{ cm} \times 1.01 \text{ cm}$. What TE modes will propagate in this wave guide, if the driving frequency is $1.70 \times 10^{10} \text{ Hz}$? Suppose you wanted to excite only *one* TE mode; what range of frequencies could you use? What are the corresponding wavelengths (in open space)?

Problem 9.30 Work out the theory of TM modes for a rectangular wave guide. In particular, find the longitudinal electric field, the cutoff frequencies, and the wave and group velocities. Find the ratio of the lowest TM cutoff frequency to the lowest TE cutoff frequency, for a given wave guide. [*Caution:* What is the lowest TM mode?]