Name:	
Score:	(see next page) /out of 40 possible points

OPTI 310, **Mid-Term Exam 2, Practice** Prof. M. Kolesik

Notes for the exam:

1. **This is a closed-book, closed-notes exam.** Calculators (with no text stored) may be used during the tests and final exam. No other form of electronic device may be used (no computers, laptops, PDA's, etc). Cell phones are absolutely prohibited during tests and the final exam. Food and drink are prohibited in the exams.

2. Answer all questions.

3. **Show your work and answers on the exam paper in the space following each question. Take the space available as a hint on how much you should be writing if you approach the problem correctly.** You may use additional paper if you find it necessary: this will be provided so do not bring your own paper into the exam. If you do use extra pages, staple the extra pages to the back of your exam. Make sure your final answers are clearly indicated.

4. On any sketches, make sure that axes are labeled and that important graphical trends are clear (such as amplitude, sign, or spatial considerations, etc.). If they are not clear enough, you may add a few words explaining what trends should be visible in the sketch.

5. Vector quantities should be distinguished by an overarrow such as $\vec{A}$.

CONSTANTS and FORMULAE of potential use in this exam:

$$r_\perp = \frac{n_i \cos\Theta_i - n_t \cos\Theta_t}{n_i \cos\Theta_i + n_t \cos\Theta_t} \quad , \quad t_\perp = \frac{2n_i \cos\Theta_i}{n_i \cos\Theta_i + n_t \cos\Theta_t}$$

$$r_\parallel = -\frac{n_t \cos\Theta_i - n_i \cos\Theta_t}{n_t \cos\Theta_i + n_i \cos\Theta_t} \quad , \quad t_\parallel = \frac{2n_i \cos\Theta_i}{n_t \cos\Theta_i + n_i \cos\Theta_t}$$

$$\sqrt{1+a} \approx 1 + \frac{1}{2}a + \dots$$

$$\frac{1}{v_?} = \frac{k(\omega)}{\omega} \qquad \frac{1}{v_?} = \frac{\partial k(\omega)}{\partial \omega}$$

Score:	
	/out of 40 possible points

1. (10pts) The Lorentz electron oscillator model for light-matter interactions leads to the following expression for the refractive-index $n(\omega)$ experienced by a monochromatic field of angular temporal frequency ω propagating in a medium of atom density N

$$n^2(\omega) = 1 + \frac{(Nq_e^2/\epsilon_0 m_e)}{(\omega_0^2 - \omega^2)} \tag{1}$$

with q_e and m_e the charge and mass of the electron, and ω_0 the atomic resonance frequency.

A In the derivation of the above formula, what physical effect has been neglected? In what angular frequency region does this approximation fail?

B Consider a dielectric medium for which ω_0 lies in the ultraviolet region of the spectrum. Explain why the refractive-index $n(\omega)$ will be greater than unity in the visible region.

C Sketch the qualitative variation of $n(\omega)$ versus ω in the visible region of the spectrum based on Eq. (1). Indicate on the horizontal axis the location of ω_0.

D Does your sketch correspond to normal or anomalous chromatic dispersion?

E The group velocity in a dispersive medium is given by $v_g(\omega) = \frac{c}{n}\left(1 + \frac{\omega}{n}\frac{\partial n}{\partial \omega}\right)^{-1}$. Explain whether the group velocity is greater than or less than the phase velocity $v_p(\omega)$ in the visible region. Justify your answer using the given formula.

2. (10pts) An electromagnetic plane wave propagates along the direction given by a vector $(+0, 1, 2)$. It is LHC polarized, with the electric field magnitude of E_0. This wave is incident (from air) on an air-glass interface. The refractive index of the glass is $n = \sqrt{2}$. The glass-air interface coincides with the plane specified by the equation $y = 0$.

A (1pts) Calculate the unit vector $\hat{u}$ in the direction of propagation.

B (1pts) Specify the unit normal vector $\hat{n}$ of the interface. Orient this vector such that it points away from the medium from which the wave propagates.

C (1pts) Determine the plane of incidence by calculating its normal unit vector $\hat{s}$

D (1pts) Specify $\hat{e}_s$, the unit polarization vector for the s-polarized wave.

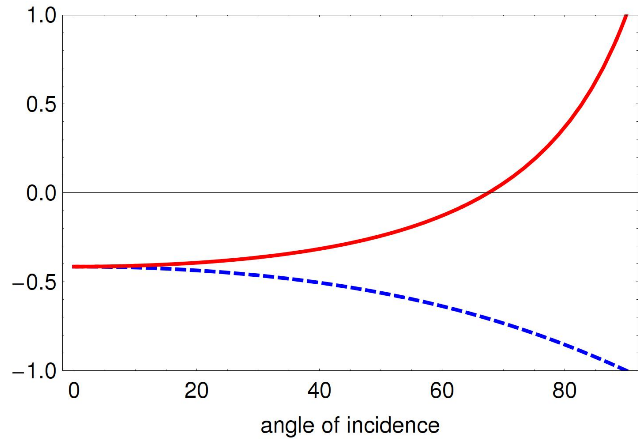
E (1pts) Calculate $\hat{e}_p$, the unit polarization vector for the p-polarized wave.

H (1pts) Determine the fractions of power in the incident beam that propagates in the s and p polarized waves.

F (2pts) Evaluate the amplitude transmission and reflection coefficients for both polarizations for the given value of n.

G (2pts) Calculate the total fractions of the power that is reflected from and transmitted through the material interface.

3. (10pts) This problem deals with Fresnel formulas.



A (1 pts) Does this picture correspond to internal or external incidence? Why?

B (4 pts) Which of the quantities r_s, r_p, t_s, t_p quantities are shown? Specify and justify your answer for each curve.

C (2 pts) Show the Brewster angle in the picture, and estimate its value.

D (3 pts) Describe at least two different ways to estimate the relative index of refraction for the interface in question. Evaluate your estimates.