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

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

In-class exam, Friday Nov. 4, 2016.
11:00-11:50 am

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:

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

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

$$r_s = \frac{\cos\Theta_i - \sqrt{n^2 - \sin^2\Theta_i}}{\cos\Theta_i + \sqrt{n^2 - \sin^2\Theta_i}} \quad , \quad t_s = \frac{2\cos\Theta_i}{\cos\Theta_i + \sqrt{n^2 - \sin^2\Theta_i}}$$

$$r_p = -\frac{n^2 \cos\Theta_i - \sqrt{n^2 - \sin^2\Theta_i}}{n^2 \cos\Theta_i + \sqrt{n^2 - \sin^2\Theta_i}} \quad , \quad t_p = \frac{2n\cos\Theta_i}{n^2 \cos\Theta_i + \sqrt{n^2 - \sin^2\Theta_i}}$$

$$\frac{1}{1 - X^2} \sim 1 + X^2 \quad \text{for small } X$$

Score:	/out of 40 possible points

P1: (10pts) The Lorentz 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 $\omega = 2\pi c/\lambda$

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

with ω_0 the resonant frequency and $n_s > 1$ the refractive-index for frequencies far below resonance.
(A - 2pt) Write down the corresponding expression for $n^2(\lambda)$ involving the resonant wavelength λ_0, with λ the wavelength of the monochromatic field in vacuum.

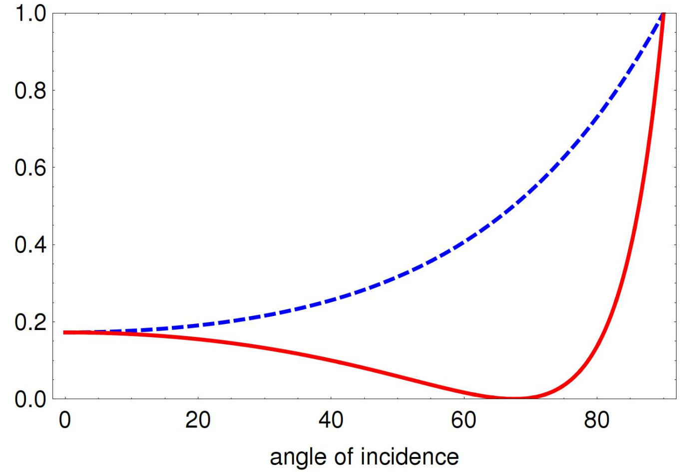
(B - 2pts) Hereafter we consider a resonant wavelength λ_0 in the ultraviolet region of the spectrum and wavelengths λ in the visible region. Starting from your expression in part (a) derive the following approximation $n^2(\lambda) = n_s^2 + C_2/\lambda^2$, where $C_2 = (n_s^2 - 1)\lambda_0^2$. Hint: you need to consider $\lambda_0 \ll \lambda$.

(C - 2pts) Given that $\lambda_0 = 0.1$ μm and $n_s = 2$ use the result of part (b) to calculate the refractive-index $n(\lambda)$ for $\lambda = 0.4$ μm and $\lambda = 0.7$ μm.

(D - 2pts) Based on the results from parts (B) and (C) sketch the form of the variation of $n(\lambda)$ versus λ in the visible region indicating key features.

(E - 2pts) Using your result from part(s) (B,D) consider $\partial n/\partial\lambda$ and ascertain the sign of this quantity in the visible region. Specify if the visible region corresponds to normal or to anomalous dispersion.

P2: (10pts) This problem deals with Fresnel formulas. The following figure depicts some of the Fresnel-formulae-related quantities (i.e. amplitude coefficients for reflection or transmission or intensity transmittance or reflectance):



A (1 pt) Is this picture showing internal or external incidence? Why?

B (4 pts) Which of the quantities $r_s, r_p, t_s, t_p, R_p, R_s, T_p, T_s$ 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. Use this estimate to calculate the refractive index of the material.

D (3 pts) Describe yet another way to estimate the relative index of refraction for the interface in question. Evaluate your estimate.