UTA EE5380 PhD Diagnosis Exam (Fall 2011)
Principles of Photonics and Optical Engineering

Instructions:

- Verify that your exam contains 7 pages (including the cover sheet).
- Some space is provided for you to show your work. Only if more space is needed, you may show your work on the back sheets.
- The point values listed on this exam serve only as a guideline. The Department reserves the right to make modifications to the weighting of the problems.
- You may use a calculator.

I Choose to work on Problems _____ and _______ (Choose only 2 from the 3 problems).

Problem	Possible Points	Scores
1	50	
2	50	
3	50	
Total Score (Choose 2 Problems)	100	

1. Yellow flame color of a birthday-cake candle originates from the D_2 fluorescence line of sodium, which consists of two spectral components centered at wavelength $\lambda_0 = 589$ nm and separated in frequency by 1.8 GHz ("hyperfine splitting"). A free-space (refractive index $n = 1$) Fabry-Perot etalon with two identical mirrors with reflectances $R = 99\%$ is used to study such sodium fluorescence light at normal incidence. The measurements show that, initially, the two spectral components of the D_2 line coincide with two consecutive etalon resonances.

    a. How large is the free spectral range of the Fabry-Perot etalon?

    b. What is the spacing d between the etalon mirrors?

    c. By what minimum distance should we move one of the etalon's mirrors in order to minimize the transmission of the fluorescence through the Fabry-Perot etalon?

    d. What is the ratio of the fluorescence power transmitted through the etalon initially to that transmitted after the adjustment of the mirror in part c?

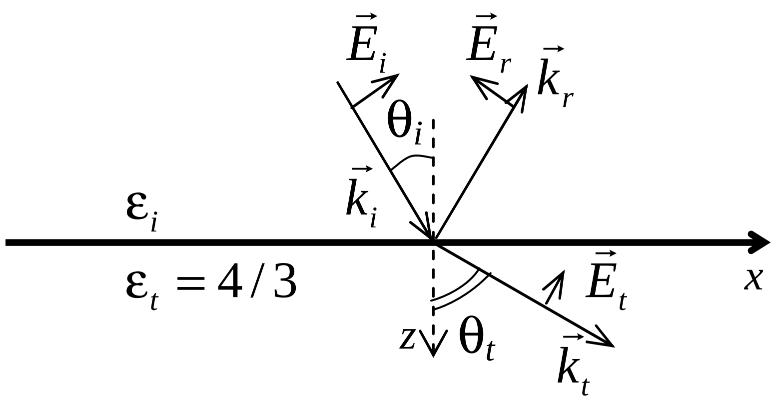
    e. What is the finesse of the etalon?

    f. How large is the full width at half-maximum $\Delta\nu_{FWHM}$ of the etalon's resonance?

2. Monochromatic plane wave falls at the plane interface between two dielectric media with permittivities ε_i and ε_t (see figure below). The magnitude of the vector of the incident electric field is

$$E_i = (6\,\text{V/m}) \times \cos[(10^7\ \text{m}^{-1})x + (\sqrt{300} \times 10^6\ \text{m}^{-1})z - (3 \times 10^{15}\ \text{s}^{-1})t]\ .$$

   a. Write the magnitude of the incident wavevector k_i .
   b. Write the wavevector $\vec{k}_i$.
   c. What are the values of frequency ν (in Hz) and radian frequency ω (in rad/s) of the incident wave?
   d. What is the value of dielectric permittivity ε_i ?
   e. What are the magnitude and orientation of incident magnetic field vector $\vec{B}_i$?
   f. What are the values of incidence angle θ_i and transmission angle θ_t ?
   g. What is the magnitude of the reflected electric field E_r ?



(problems continue on the next page)

3. Monochromatic light is sent through two ideal linear polarizers. Initially, their transmission axes were set to be parallel, and the intensity of light after the two polarizers was measured to be I_0. Then, for the purpose of all the questions from (a) to (e) below, the second polarizer has been set so that its transmission axis forms a +270º angle with that of the first polarizer. ("+" sign here is just a convention for angle measured clockwise, looking in the direction of propagation).

   a. What is the intensity of light at the output of the second polarizer?

   b. A combination of two ideal quarter-wave plates is inserted between the two polarizers; the optical axes of the quarter-wave plates are parallel to each other and also parallel to the transmission axis of the first polarizer. What is the intensity at the output of the second polarizer?

   c. What will be the intensity at the output of the second polarizer in problem 3b after the two quarter-wave plates are rotated together so that their optical axes are still parallel to each other, but now form a +45° angle with the first polarizer?

   d. What will be the intensity at the output of the second polarizer in problem 3c if only the first quarter-wave plate is rotated so that its optical axis is at +45º with respect to the transmission axis of the first polarizer, whereas the second quarter-wave plate's optical axis remains parallel to the transmission axis of the first polarizer?

   e. In the setup of problem 3d, what would be the intensity at the output of the second polarizer if the first quarter-wave plate is rotated by additional +45º so that its optical axis is at +90º with respect to the transmission axis of the first polarizer, whereas the second quarter-wave plate's orientation remains parallel to the transmission axis of the first polarizer?