UTA PhD Diagnosis Exam (Fall 2012)

Photonics and Optics

Instructions:
• Verify that your exam contains 7 pages (including the cover sheet).
• Please be sure to use blank paper to write your answers. If more space is needed, please ask the instructor for extra paper. DO NOT WRITE ON THE BACK OF A SHEET!
• The point values listed on this exam serve only as a guideline. The Dept reserves the right to make modifications to the weighting of the problems.
• Calculator is okay.

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

<table>
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<tr>
<th>Problem</th>
<th>Possible Points</th>
<th>Scores</th>
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<tbody>
<tr>
<td>1</td>
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<td>Total Score (Choose 2 Problems)</td>
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1. A 2-cm-long Fabry-Perot etalon made of material with refractive index $n_f$ has two identical mirrors with reflectances $R = 98\%$ and a free spectral range of 3.75 GHz.
   a. What is the value of the refractive index $n_f$ of the Fabry-Perot etalon?
   b. What is the value of the finesse of the etalon?
   c. How large is the full width at half-maximum $\Delta\nu_{\text{FWHM}}$ of the etalon’s resonance?
   d. A signal from a laser with wavelength $\lambda = 600$ nm is initially at resonance with the etalon, resulting in 100% transmission through the etalon. Subsequently, the resonance frequency of the etalon is gradually tuned by increasing the temperature (which slightly increases the refractive index $n_f$). As a result, transmission through the etalon at first decreases to a minimum value $T_{\text{min}}$, and then increases to reach 100% transmission again (i.e., laser frequency now coincides with the next resonance of the etalon). By how much has the refractive index $n_f$ changed between the two 100% transmission cases?
   e. What was the minimum transmission value $T_{\text{min}}$ in problem d?
2. (Note: some angles in the Figure 1 below are intentionally distorted.) A beam of light travels through a right-triangular prism made of a dielectric with refractive index $n > 1$. The beam has zero reflection at the two prism-air interfaces A and B.

a. Plane of incidence is the plane containing the wavevector $\vec{k}$ and the vector normal to the interface (i.e., it is the plane of the problem sheet). What is the orientation of the electric field vector in this problem: is it parallel or perpendicular to the plane of incidence?

b. What is the angle of incidence $\gamma$ onto the second prism-air interface B?

c. What is the angle of incidence $\beta$ onto the first prism-air interface A?

d. What is the value of refractive index $n$?

![Figure 1](image-url)

(problems continue on the next page)
3. A combination of two lenses with focal distances $f_1 = +30$ cm and $f_2 = -20$ cm, separated by distance $d = 40$ cm, is used to create an image of a real object located at a distance 75 cm from the first lens (i.e. from the lens with focal distance $f_1$).

a. Find the location of the image created by this 2-lens combination.

b. Is this final image real or virtual?

c. Is the final image erect or inverted (with respect to the original object)?

d. Is the final image magnified or reduced (compared to the original object)? Find the magnification (or reduction) factor.

e. Subsequently, the setup is changed by relocating the second lens (i.e., negative lens with focal distance $f_2$) to a new position, so that the final image created by the 2-lens combination is now located at the infinity. What is the new distance $d$ between the two lenses?