UTA PhD Diagnosis Exam (Spring 2012)

Photonics and Optics

Instructions:
• Verify that your exam contains 10 pages (including the cover sheet).
• Some space is provided for you to show your work. 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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<td>1</td>
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1. You are given the half-cylinder with radius $R$, shown in Fig. 1 below and made of a transparent dielectric material with refractive index $n_c = 1.90$. A drop of liquid is placed on its surface as shown. It is known that the liquid has refractive index $n_{\text{liq}}$ somewhere in the range 1.33–1.65 (this is the range from water to oil). You are also given a polarized HeNe laser with wavelength of 633 nm that you can orient at will and a device to measure angles. Describe two good methods to find $n_{\text{liq}}$ using this gear.

Fig. 1.
2. A monochromatic plane wave with wavelength \( \lambda = 600 \text{ nm} \) propagates at normal incidence from air (refractive index 1) into a dielectric with refractive index \( n_s \), separated from the air by a dielectric slab with refractive index \( n_1 = 1.5 \) and thickness \( d \) (see Fig. 2 below). The reflected-wave power can be minimized by exploiting two-beam interference from the reflecting surfaces. What are the values of the thickness \( d \) that minimize the reflected power for the cases of

   a. \( n_s > n_1 \); 
   b. \( n_s < n_1 \)?

Fig. 2.
3. A numerical aperture NA of a dielectric waveguide (e.g., optical fiber) is defined as the maximum value of \( \sin \theta \) (with \( \theta \) being the angle of incidence at the input face of the waveguide, see Fig. 3 below) for which the incident beam can propagate in the waveguide under the condition of total internal reflection (i.e., under condition that angle \( \varphi \) in Fig. 3 is greater than the critical angle of the total internal reflection). Assuming that the core A of the waveguide has a refractive index \( n_1 = 1.51 \) and the cladding B has a refractive index \( n_2 = 1.49 \), find the numerical aperture \( NA = \sin \theta_{\text{max}} \) of the waveguide.