UTA PhD Diagnosis Exam (Spring 2013)

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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<tr>
<td>1</td>
<td>50</td>
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<td>2</td>
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<td>3</td>
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<td>Total Score (Choose 2 Problems)</td>
<td>100</td>
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1. A collimated laser beam of power $P = 3$ Watt illuminates a 100%-reflecting micromirror of mass $m = 1$ microgram at an angle of incidence $\theta = 60^\circ$ for duration of $\tau = 10$ milliseconds. Prior to laser illumination, the mirror is at rest. What is the velocity of the mirror after the laser illumination? *(Hint: Use the conservation of momentum.)*
2. Monochromatic light is sent through a sequence of two ideal linear polarizers. The transmission axis of the second (i.e., output) polarizer is at an angle $\alpha = +70^\circ$ with respect to the transmission axis of the first (i.e., input) polarizer (“+” sign here is just a convention for angle measured clockwise, looking in the direction of propagation). A combination consisting of a half-wave plate (HWP) followed by a quarter-wave plate (QWP) is inserted between the polarizers (note that the HWP occurs before the QWP in the beam path). The optical axis of the QWP is parallel to the transmission axis of the second polarizer.

a. What should be the angle $\gamma$ of the HWP’s optical axis with respect to the transmission axis of the first polarizer, if we want to achieve zero transmission after the second polarizer? (Note that there are several solutions; it is sufficient for you to provide one.)

b. What should be the angle $\gamma$ of the HWP’s optical axis with respect to the transmission axis of the first polarizer, if we want to achieve maximum transmission after the second polarizer? (Note that there are several solutions; it is sufficient for you to provide one.)
3. A monochromatic plane wave falls from the air (refractive index $n_i = 1$) onto a flat interface with a dielectric medium of refractive index $n_t = \sqrt{3}$ at an angle of incidence $\theta_i = 60^\circ$ (see the figure below; z-axis in the figure points from the plane of the problem sheet toward the reader). The incident electric field vector is in the plane of incidence (i.e., in plane of the problem sheet), and its magnitude is given by

$$E_i = (600 \text{ V/m}) \times \cos(3 \times 10^{15} \text{ rad/s}) t.$$

a. What are the values of radian frequency $\omega$ (in rad/s) and frequency $\nu$ (in Hz) of the incident wave?

b. Find the magnitude of the incident wavevector $k_i$.

c. Write the wavevector $k_i$.

d. What are the magnitude and orientation of the incident magnetic field vector $B_i$?

e. What is the value of the transmission angle $\theta_t$?

f. Write the wavevector $k_t$ of the transmitted field.

g. What is the magnitude of the reflected electric field $E_r$?

\[
\begin{align*}
\text{index } n_i &= 1 & \text{air} & \theta_i & k_i \\
\text{index } n_t &= \sqrt{3} & \text{dielectric} & \theta_t & k_t
\end{align*}
\]