Exam #1
Wave Motion and Optics
Physics 325
February 19, 2007

<table>
<thead>
<tr>
<th>Problem</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
1. A plane wave of light moving to the right strikes a wedged piece of glass (index $n = 1.5$). The wedge angle $\alpha \ll 1$. The glass is surrounded by absorbing material, as shown. Answer these questions:
   a) What direction (up/down) will the light exit the glass?
   b) At what angle with respect to the horizontal?
   c) If a lens of focal length $f$ is placed to the right of the wedge, where the light be focused?
   d) If the glass has a size $D$, estimate the resulting size of the focused spot.
2. A 1 mm tall object is placed 5 cm from an $f = 10$ cm lens. Light from the object subtends angle $\alpha$.
   a) Where is the image, and what size is it?
   b) What would you need to do to see it?
   c) A second lens, $f_2 = 10$ cm, is now placed 10 cm to the right of the first lens. Where is the new image and what is its height?
   d) At what angle does light from the object that passes through the center of the first lens reach the image?
3. A set of 15 very narrow slits arranged in a line and separated by a distance $d$ is illuminated by a plane wave of wavelength $\lambda$ at normal incidence.
   a) At positions of constructive interference far away from the slits, what is the observed intensity relative to that of a single slit?
   b) At what angles (with respect to the incident plane wave) will the constructive interference occur?
   c) The center 5 slits are blocked. Quantitatively explain how the intensities at various angles change.
4. The Fourier Transform of a circular hole of radius $a$ is

$$\pi a \frac{2J_1(qa)}{qa}$$

A plot of $2J_1(u)/u$ is shown to the right.

a) A plane wave of wavelength $\lambda$ is sent through the hole. Calculate the diffraction pattern observed a large distance $z$ from the hole.

b) What is the approximate width of the diffraction pattern?

c) A lens of focal length $f$ is placed a distance $s < f$ in front of the hole. Where will the diffraction pattern be smallest and what will its approximate width be?