Reflection and Refraction Test Review

Note: Huygens Principle was inadvertently left off of this review sheet. You must know what it is. It is in the last lab manual reading packet.

1. Define: **Answers are all in Reflection & Refraction Reading Packet except as indicated.**

<table>
<thead>
<tr>
<th>Term</th>
<th>Reflection &amp; Refraction Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermat’s principle</td>
<td>critical angle</td>
</tr>
<tr>
<td>total internal reflection</td>
<td>refraction</td>
</tr>
<tr>
<td>focal point</td>
<td>optical fiber</td>
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<tr>
<td>virtual image</td>
<td>spherical aberration</td>
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<tr>
<td>law of reflection</td>
<td>astigmatism</td>
</tr>
<tr>
<td>incident angle</td>
<td>concave lens</td>
</tr>
<tr>
<td>focal length</td>
<td>focal plane</td>
</tr>
<tr>
<td>real image</td>
<td>chromatic aberration</td>
</tr>
<tr>
<td>Snell’s law</td>
<td>In First Reflection &amp; Refraction Notes</td>
</tr>
<tr>
<td></td>
<td>nearsightedness</td>
</tr>
<tr>
<td></td>
<td>principal axis</td>
</tr>
</tbody>
</table>

2. Review all experimental procedures including:
   - Fermat’s brainbuster
   - reflection experiment
   - refraction experiment
   - convex lens

3. List and explain some of the optical effects caused by refraction. **In First Reflection & Refraction Notes**

4. List and explain lens and eye defects and how to correct them.

5. List applications of optical fibers.

6. Calculate the speed of light and wavelength of electromagnetic radiation in a medium given refractive index. **In First Reflection & Refraction Notes**

7. Calculate refraction index using incident and refracted angle. **In First Reflection & Refraction Notes**

8. What kind of waves diffract the most? **In Light Waves Reading Packet**

9. List the electromagnetic spectrum in order from longest wavelength to shortest wavelength. **Electromagnetic Spectrum Table**

10. Explain what would happen if a light source was pointed toward the three Polaroid filters shown below in order and why. **In Polarization Notes**

11. Explain what would happen if you took the middle filter out and why. **In Polarization Notes**

12. What does constructive interference look like for light waves? **In Light Waves Reading Packet**

13. What does destructive interference look like? **In Light Waves Reading Packet**

14. When is diffraction most pronounced? **In Light Waves Reading Packet**

15. What did Thomas Young do? **In Light Waves Reading Packet**

16. List the advantages and disadvantages of diffraction. **In Light Waves Reading Packet**

17. Describe how to make a view master cartridge with a regular camera. **In Polarization Notes**
Sample Problems
1. A beam of light with vacuum wavelength 550 nm traveling in air is incident on a slab of transparent material. The incident beam makes an angle of 40º with the normal, and the refracted beam makes an angle of 26º with the normal. Find the index of refraction of the material.

\[ n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} = \frac{(1.000293) \sin 40^\circ}{\sin 26^\circ} = 1.47 \]

2. For the above problem, find the wavelength of light in the material.

\[ \lambda = \frac{\lambda_0}{n} = \frac{550 \text{ nm}}{1.47} = 375 \text{ nm} \]

3. A light ray of wavelength 589 nm traveling through air is incident on a smooth, flat slab of crown glass at an angle of 30º to the normal. Find the refraction angle.

\[ \sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1.000293) \sin 30^\circ}{1.517} = 0.3297 \]

\[ \theta_2 = 19.3^\circ \]

4. Light of wavelength 589 nm in vacuum passes through a piece of fused quartz whose index of refraction is 1.458. Find the speed of light in the quartz.

\[ v = \frac{c}{n} = \frac{3 \times 10^8 \text{ m/s}}{1.458} = 2.1 \times 10^8 \text{ m/s} \]

5. Find the frequency of the light passing through the quartz.

\[ f = \frac{c}{\lambda_0} = \frac{3 \times 10^8 \text{ m/s}}{589 \text{ nm}} = 5.1 \times 10^{14} \text{ Hz} \]
6. A light beam passes from air through a thick slab of material whose index of refraction is \( n_2 \) back into air. Prove mathematically that the emerging beam is parallel to the incident beam.

Prove: \( \Theta_1 = \Theta_2 \)

Given: Angles Shown

<table>
<thead>
<tr>
<th>Conclusion</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( n_1 \sin \theta_1 = n_2 \sin \theta_2 )</td>
<td>Snell’s Law</td>
</tr>
<tr>
<td>( n_2 \sin \theta_3 = n_1 \sin \theta_4 )</td>
<td>Alternate Interior Angles Are Congruent</td>
</tr>
<tr>
<td>2. ( \Theta_2 = \Theta_1 )</td>
<td>Algebraic Substitution</td>
</tr>
<tr>
<td>( \frac{n_2 \sin \theta_2}{n_2 \sin \theta_2} = \frac{n_1 \sin \theta_1}{n_1 \sin \theta_4} )</td>
<td>Algebraic Division</td>
</tr>
<tr>
<td>4. ( \sin \theta_1 = \sin \theta_4 )</td>
<td></td>
</tr>
<tr>
<td>( \theta_1 = \theta_4 )</td>
<td></td>
</tr>
</tbody>
</table>

7. The index of refraction for benzene is 1.501, 1.361 for ethyl alcohol, and 1.473 for glycerin. Find the speed of light in each of these mediums.

\[
v_{\text{benzene}} = \frac{c}{n_{\text{benzene}}} = \frac{3 \times 10^8 \text{ m/s}}{1.501} = 2.0 \times 10^8 \text{ m/s}
\]

\[
v_{\text{ethanol}} = \frac{c}{n_{\text{ethanol}}} = \frac{3 \times 10^8 \text{ m/s}}{1.501} = 2.2 \times 10^8 \text{ m/s}
\]

\[
v_{\text{glycerin}} = \frac{c}{n_{\text{glycerin}}} = \frac{3 \times 10^8 \text{ m/s}}{1.501} = 2.0 \times 10^8 \text{ m/s}
\]

8. A light ray in air is incident on a water surface at an angle of 30º with respect to the normal to the surface. What is the angle of the refracted ray relative to the normal to the surface?

\[
n_1 \sin \theta_1 = n_2 \sin \theta_2
\]

\[
\sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1.000293)\sin 30º}{1.333} = 0.3752
\]

\[
\theta_2 = 22.0º
\]
9. A ray of light is incident on the surface of a block of clear ice at an angle of 40º with the normal. Part of the light is reflected and part is refracted. Find the angle between the reflected and refracted glass.
\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]
\[ \sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1.000293) \sin 40^\circ}{1.310} = 0.4908 \]
\[ \theta_2 = 29.4^\circ \]
\[ \phi = 180^\circ - 40^\circ - 29.4^\circ = 111^\circ \]

10. A diamond is foolishly cut into a flat slab that is 0.50 cm thick. Find the time required for light to travel through this slab.
\[ v = \frac{c}{n} = \frac{3 \times 10^8 \text{ m/s}}{2.409} = 1.2 \times 10^8 \text{ m/s} \]
\[ t = \frac{\Delta x}{v} = \frac{0.5 \times 10^{-2} \text{ m}}{1.2 \times 10^8 \text{ m/s}} = 4.0 \times 10^{-11} \text{s} \]

11. If light is incident on the flat diamond slab at an angle of 45º to the normal, what is the refracted angle?
\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]
\[ \sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1.000293) \sin 45^\circ}{2.409} \]
\[ \theta_2 = 17.1^\circ \]

12. If a He-Ne laser beam is incident on the diamond slab at an angle of 22º to the normal, what is the refracted angle?
\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]
\[ \sin \theta_2 = \frac{n_1 \sin \theta_1}{n_2} = \frac{(1.000293) \sin 22^\circ}{2.409} \]
\[ \theta_2 = 8.9^\circ \]

13. A light ray initially in water enters a transparent substance at an angle of 37º with respect to the normal, and the transmitted ray is refracted at an angle of 25º. Calculate the speed of light in the transparent substance.
\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]
\[ n_2 = \frac{n_1 \sin \theta_1}{\sin \theta_2} = \frac{(1.33) \sin 37^\circ}{\sin 25^\circ} = 1.89 \]
\[ v = \frac{c}{n} = \frac{3 \times 10^8 \text{ m/s}}{1.89} = 1.6 \times 10^8 \text{ m/s} \]