HOMEWORK PROBLEM SET 1

1. A ray of light in air is incident on the polished surface of a piece of glass at an angle of $10^\circ$. What percentage error in the angle of refraction is made by assuming that the sines of angles in Snell's law can be replaced by the angles themselves? Assume $n(\text{glass}) = 1.4$.

2. A light beam, consisting of a mixture of blue, yellow, and red light, is incident perpendicular on the face of a symmetric $90^\circ$ prism as indicated. The refractive index of the prism is:

   - $n = 1.420$ for blue light
   - $n = 1.410$ for yellow light
   - $n = 1.400$ for red light

Determine and describe with a sketch how the incident light beam proceeds for the three colors both in refraction and reflection at surface A.

3. Verify that when a wave passes through a medium limited by plane parallel sides, the direction of propagation of the emergent ray is parallel to that of the incident ray. Compute the lateral displacement of the rays as a function of the medium thickness, the medium's index of refraction and the angle of incidence.

4. Two plane mirrors are inclined to each other with angle $\theta$ ($<90^\circ$). Applying the law of reflection, show that any ray whose plane of incidence is perpendicular to the line of intersection is deviated in the two reflections by an angle which is independent of the angle of incidence. Show that in the special case of a corner mirror ($\theta = 90^\circ$) the rays are deviated by $180^\circ$ (retroreflection).

5. There is a long slab waveguide ($n_2 > n_1$) as shown in the figure. We consider light beams which enter only from air to the inner layer ($n_2$). Assume $n_{\text{air}} = 1.000$.

   (a) What is the maximum incident angle $\theta_{\text{max}}$ for the incident light to be guided inside the slab by total internal reflection at the interfaces between the inner ($n_2$) and outer ($n_1$) layers? What is the angle when $n_1 = 1.623$ and $n_2 = 1.650$?

   (b) What is the time-difference between the fastest beam (normal incidence) and the slowest one (maximum incident angle) after the light beams pass through the slab?
of $L = 1$ km length? Use the values of $n_1$ and $n_2$ given in (a).