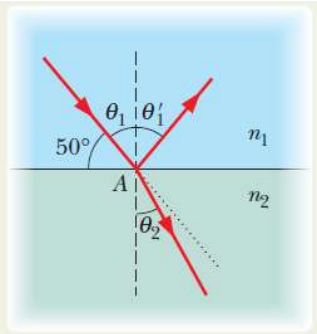
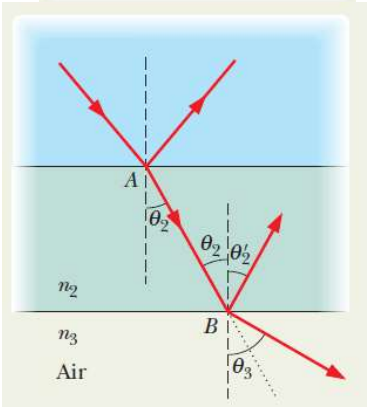
Reflection and Refraction



1. HR.p910. A beam of monochromatic light reflects at point A on the interface between material 1 with index of refraction $n_1 = 1.33$ and material 2 with index of refraction $n_2 = 1.77$. The incident beam makes an angle of $50°$ with the interface. The light that enters material 2 at point A then reaches point B on the interface between material 2 and material 3, which is air. The interface through B is parallel to that through A. At B, some of the light reflects and the rest enters the air.
   a. What is the angle of reflection at point A?
   b. At pint B, what is the angle of reflection and what is the angle of refraction into the air?

Answer: $29°$; $59°$

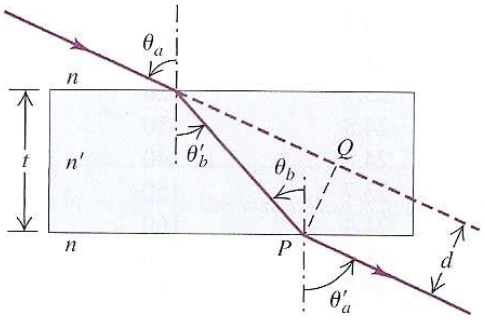


2. YF.33.58. (or BW.SP.32.2) Light is incident in air at an angle θ_a on the upper surface of a transparent plate of thickness$t$, the surfaces of the plate being plane and transparent to each other.

a. Prove that $\theta_a = \theta_a{}'$

b. Show that this is true for any number of different parallel plates.

c. Prove that the lateral displacement d of the emergent beam is given by the relationship $d = t\,\frac{\sin(\theta_a - \theta_b{}')}{\cos(\theta_b{}')}$



d. A ray of light is incident at an angle of $66°$ on one surface of a glass plate $2.4\ cm$ thick with the index of refraction of 1.8. The medium on the other side of the plate is air. Find the lateral displacement between the incident and the emergent ray.

Answer: $1.6\ cm$

Total Internal Reflection

3. BW.SP.32.3. Consider a long optical fiber with index of refraction $n = 1.265$ that is surrounded by air. There is no cladding. The end of the fiber is polished to be flat and is perpendicular to the length of the fiber. A light ray from a laser is incident from air onto the center of the circular face of the fiber. What is the maximum angle of incidence for this light ray such that it will be confined and transported by the optical fiber? Neglect the reflection as the light ray enters the fiber.

Answer: $50.78°$

4. YF.33.52. Light is incident normally on the short face of a $30° - 60° - 90°$ prism. A drop of liquid is placed on the hypotenuses of the prism. If the index of refraction of the prism is 1.62,

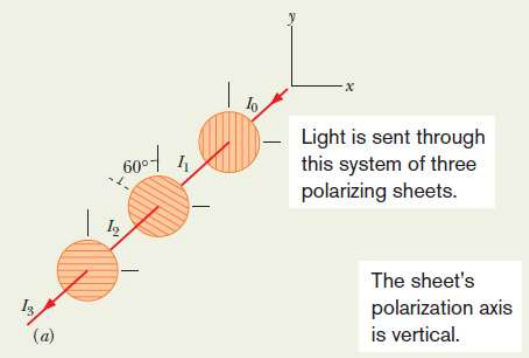
a.find the maximum index that the liquid can have if the light is to be totally reflected;

b. how would the result change if the whole prism were to be immersed in this liquid?

Answer: 1.4

Polarization

5. HR.p904. Un-polarized light is passing through a system of three polarizing sheets as shown in the figure.
a) What fraction of the initial intensity I_0 of the light emerges from the three-sheet system?
b) In which direction is that emerging light polarized?
Answer: 9.4%



6. BW.31.53. A laser is producing light that is polarized in the vertical direction. The light travels in the positive x-direction and passes through two polarizers, which have polarizing angles of $35°$ and $55°$ from the vertical. The laser beam has a circular cross section with a diameter of $1\ mm$ and has an average power of $15\ mW$ before entering the polarizers. After the polarizers:
a. What are the magnitudes of the electric and magnetic fields?
b. What is the intensity of the laser light?
Answer: $2.9\ 10^3\ \frac{V}{m}$; $9.7\ 10^{-6}\ T$; $11.3\ \frac{kW}{m^2}$