1. You look down at a coin that lies at the bottom of a pool of liquid with depth \(d = 17.5\) cm and index of refraction \(n = 1.33\). [see Fig. 3-8 (b) in text] Because you view with two eyes, which intercept different rays of light from the coin, you perceive the coin to be where the extensions of the intercepted rays cross (at \(S'\) in figure), at an apparent depth closer to you than depth \(d\). Assume that the intercepted rays are near vertical so we can say that \(\tan \theta = \sin \theta = \theta\) in radians, and find the apparent depth \(d'\) of the coin.

Note: draw a clear diagram (like the one in the book), labeling the angle \(\theta\), the angle \(\theta'\), the distance \(d\), and the apparent distance \(d'\), of the coin.

2. A converging thin lens of focal length +5.0 cm and a diverging thin lens of focal length -15.0 cm are placed in contact. Find the effective focal length of the system of these two lenses.

3. Unpolarized light is incident on 3 linear polarizers whose transmission axes make angles of 0º, 20º, and 50º respectively. What fraction (or per cent) of the incident irradiance is transmitted through the final polarizer?

4. (a1) A laser beam shines from glass (\(n = 1.50\)) into water (\(n = 1.33\)). Sketch the light ray incident on the interface, showing the parallel and perpendicular polarizations [TE and TM] (using appropriate symbols). Show also the transmitted and reflected ray with their polarizations. Assume that the incident angle is the polarizing angle.
(a2) At what incident angle is the reflected light completely polarized?
(b1) If the same laser is incident from the water into the glass, what will change about your diagram in (a)?
(b2) Calculate the polarizing angle in this case.

5. (a) How thick should a quarter-wave plate made from MgF\(_2\) [\(n_o = 1.3836, n_e = 1.3957\)] be for light of wavelength 405 nm be? Show calculation.
(b) How thick should a half-wave plate made from calcite [\(n_o = 1.6557, n_e = 1.4852\)] be for light of wavelength 633 nm be? Show calculation.

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7. Briefly explain how to make a circular polarizer from a piece of polaroid material and a wave-plate. Be specific about angles and type of wave-plate.

8. 3 polarizers are set up as follows:
- polaroid 1 has its transmission axis horizontal
- polaroid 2 is rotating at a constant frequency of 0.5 Hz; at \(t = 0\), its axis is horizontal
- polaroid 3 has its transmission axis vertical.

Sketch the intensity (= irradiance) of light transmitted by these polarizers as a function of time from \(t = 0\) to \(t = 4\) sec.