MASSACHUSETTS INSTITUTE OF TECHNOLOGY

2.71 Optics **Fall '05**
Problem Set #2 Posted Sept. 14, 2005 — Due Wednesday, Sept. 21, 2005

1. **The spoon** Compare the image of yourself that you observe looking at the convex surface of a spoon with the image from a flat mirror. Do some simple raytracing to explain the difference.

2. **Anamorphic demagnifier** Consider the geometry shown in Figure 2, which uses a right-angle prism to laterally translate a horizontal incident ray. The ray experiences TIR at the first two glass-air interfaces and exits at the third interface. The prism has index of refraction n and a tip angle θ.

   a) If $\theta = 15^o$, find n so that the outgoing ray propagates in the horizontal direction, as shown in the Figure 2.

   b) Calculate the vertical demagnification ratio

   $$m = \frac{h_2}{h_1}$$

   when $\theta = 15^o$.

   c) Can the requirement of horizontal orientation for the outgoing ray be satisfied if $\theta = 45^o$?

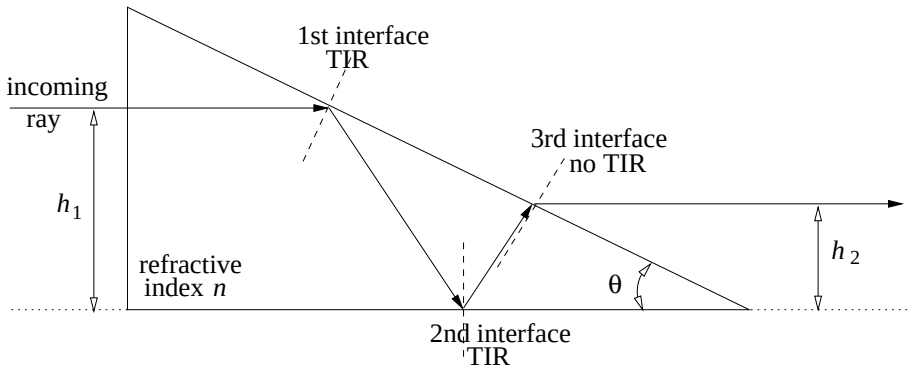

Figure 2

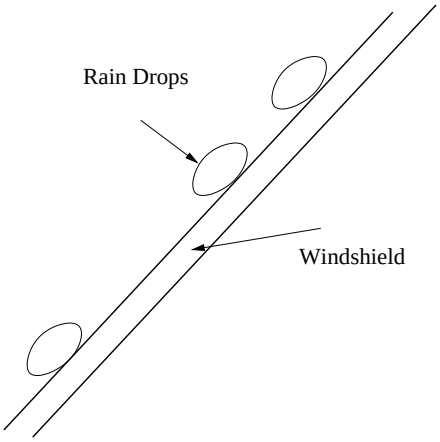

Figure 3

3. Design an optical system which can detect the amount of water present on a car's windshield to adjust the wiper speed.

Hint: indices of refraction $n_{\text{glass}} = 1.5, n_{\text{water}} = 1.33, n_{\text{air}} = 1.0$.

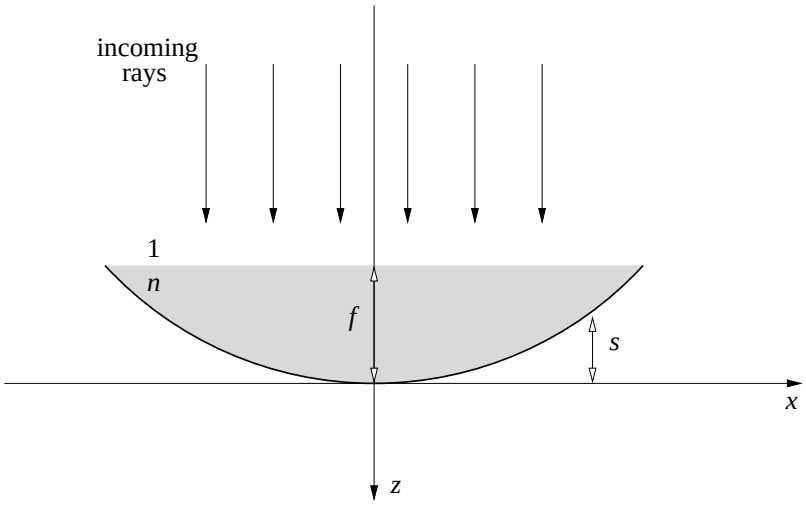

Figure 4

(Please turn over)

4. **Lens-in-a-pool** Consider a perfectly focussing one-dimensional paraboloid mirror filled with a fluid of refractive index n. The mirror surface is described by the equation $s(x) = x^2/4f$, where f is the focal length of the mirror. The fluid is present up to a height of f. Light is incident from the top as shown in Figure 4. You may neglect the slight reflection that occurs when the light rays go from the air into the fluid.

   a) Calculate the portion of the incoming ray bundle which will exit from the fluid as a divergent ray bundle after focusing.

   b) Show that the remaining rays will exit as a parallel ray bundle.