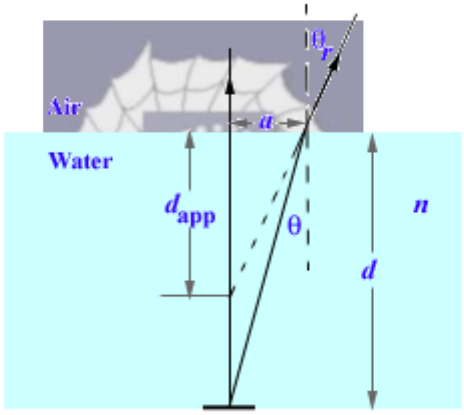
592.

Problem 43.17 (RHK)

A coin lies at the bottom of a pool with depth d and index of refraction n; as shown in the figure. We have to show that light rays that are close to the normal appear to come from a point $d_{app} = d/n$ *below the surface. This distance is called the apparent depth of the pool.*



Solution:

As shown in the figure, we view the coin from air close to the normal. Therefore, the angle of incidence θ is small and we use the small angle approximation $\sin\theta \,;\; \theta$.

From Snell's law we find the angle of refraction θ_r.

$n\sin\theta = \sin\theta_r$.

In the small angle approximation, we have

$\theta_r \; ; \; n\theta \; ,$

where *n* is the index of refraction of water with respect to air. As the depth of the pond is *d*, we note

$a = d \tan\theta \; ; \; d\theta,$

and

$a = d_{app} \tan\theta_r \; ; \; d_{app}\theta_r .$

This gives that

$$d_{app} = \frac{\theta}{\theta_r} d = \frac{d}{n}.$$