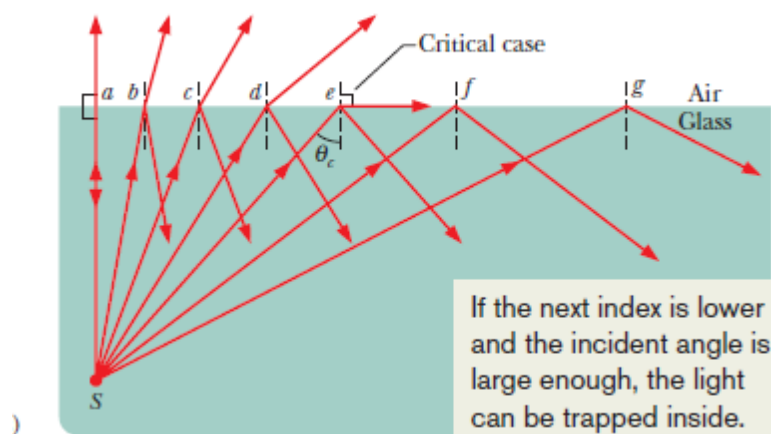


Total Internal Reflection

Figure below shows rays of monochromatic light from a point source S in glass incident on the interface between the glass and air. For ray a , which is perpendicular to the interface, part of the light reflects at the interface and the rest travels through it with no change in direction.

For rays b through e , which have progressively larger angles of incidence at the interface, there are also both reflection and refraction at the interface. As the angle of incidence increases, the



angle of refraction increases; for ray e it is 90° , which means that the refracted ray points directly along the interface. The angle of incidence giving this situation is called the **critical angle** θ_c . For angles of incidence larger than θ_c , such as for rays f and g ,

there is no refracted ray and *all* the light is reflected; this effect is called **total internal reflection** because all the light remains inside the glass.

To find θ_c , we use law of reflection ($n_1 \sin \theta_1 = n_2 \sin \theta_2$); we arbitrarily associate subscript 1 with the glass and subscript 2 with the air, and then we substitute θ_c for θ_1 and 90° for θ_2 , which leads to

$$n_1 \sin \theta_c = n_2 \sin 90^\circ,$$

which gives us

$$\theta_c = \sin^{-1} \frac{n_2}{n_1} \quad (\text{critical angle}).$$

Because the sine of an angle cannot exceed unity, n_2 cannot exceed n_1 in this equation. This restriction tells us that total internal reflection cannot occur when the incident light is in the medium of lower index of refraction. If source S were in the air in Fig. 33-23a, all its rays that are incident on the air–glass interface (including f and g) would be both reflected *and* refracted at the interface.

Applications

Total internal reflection has found many **applications** in medical technology. For example, a physician can view the interior of an artery of a patient by running two thin bundles of *optical fibers* through the chest wall and into an artery. Light introduced at the outer end of one bundle undergoes repeated total internal reflection within the fibers so that, even though the bundle provides a curved path, most of the light ends up exiting the other end and illuminating the interior of the artery. Some of the light reflected from the interior then comes back up the second bundle in a similar way, to be detected and converted to an image on a monitor's screen for the physician to view. The physician can then perform a surgical procedure, such as the placement of a stent.