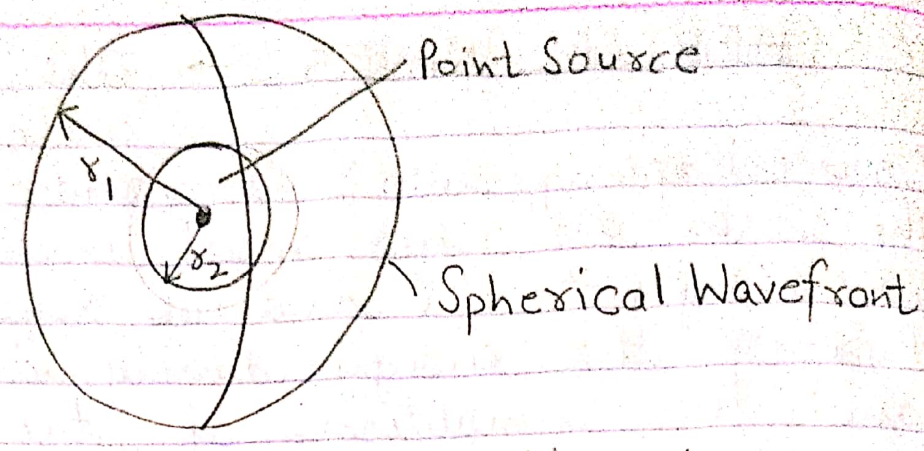


Fig: Spherical waves expanding from a point source

Total Integral Reflection - Critical Angle →

From Snell, we have the relation:

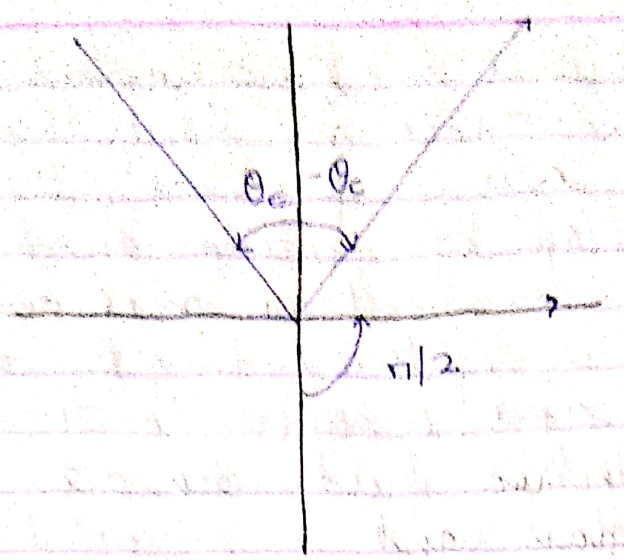
$$\sin[\theta_2] = \frac{n_1}{n_2}\sin[\theta_1]$$

If $n_1 > n_2$ then a specific angle θ_1 ~~satisfies~~ ~~angle θ_1~~ the condition:

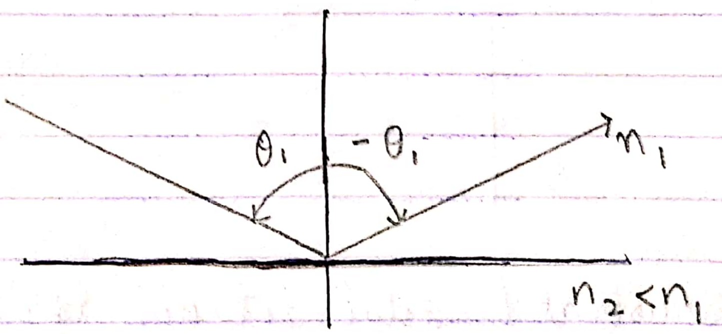
$$\frac{n_1}{n_2}\sin[\theta_1] = 1 \Rightarrow \sin[\theta_1] = \frac{n_2}{n_1} < 1 \Rightarrow \theta_2 = \frac{\pi}{2}$$

which means that the outgoing ray is refracted parallel to the interface ("surface"). The incident angle θ_1 that satisfies this condition is the critical angle θ_c

$$\theta_c = \sin^{-1}\left[\frac{n_2}{n_1}\right]$$



If the incident angle $\theta_1 > \theta_c$ and $n_1 > n_2$ (e.g., the first medium is glass & the second is air), then no real-valued solution for Snell's law exists, & there is no reflected light. This is the well-known phenomenon of total internal reflection - all of the incident light is reflected at the interface.



This may be analyzed rigorously by applying Maxwell's equations to show that the refracted angle θ_2 is complex valued, not real, and that the electromagnetic field is attenuated exponentially as it crosses the interface. In other words, the electric field decays so rapidly across the interface that no energy can flow across the boundary, and hence no light escapes. However, we can "frustrate" the total internal reflection by placing another medium (such as another piece of glass) within a few light wavelengths of the interface. If close enough to the boundary, then some electric field can get into the second glass and a refracted wave "escapes".

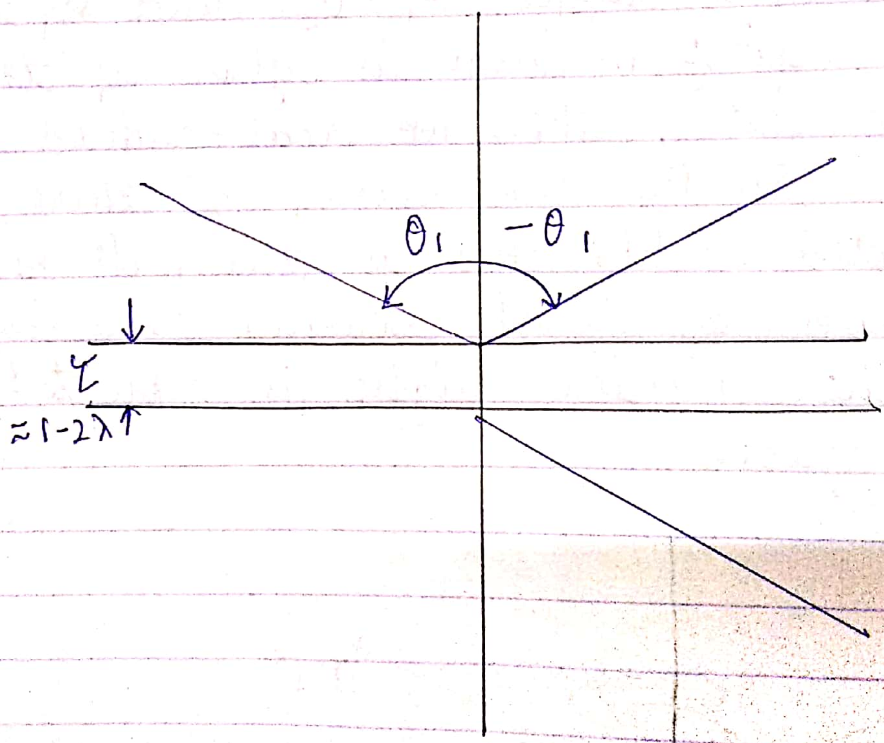


Fig: Frustrated total internal reflection