Key Concepts

Chapter 10

Snell's law

Index of refraction

$n_1 \sin \theta_1 = n_2 \sin \theta_2$

Takeaways

Snell's law gives the relationship between angles of incidence and refraction for a wave striking an interface between two media with different indices of refraction.

Observe that total internal reflection only occurs when the wave is passing from a medium with a higher index of refraction (lower speed) to a medium with a lower index of refraction (higher speed). This is true because the sine cannot be greater than 1.

Things to Watch Out For

The angles in Snell's law are always measured relative to the surface normal.

Refraction

Light is refracted as it travels from a liquid into air unless the angle of incidence is greater than or equal to 51°; otherwise, no light is refracted. What is the index of refraction of the liquid?

1) Write Snell's law.

Use Snell's law to write an equation relating the indices of refraction in the two media to the angles in those media. The angles, θ_1 and θ_2, are measured relative to the surface normals.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$
$$n_{liquid} \sin \theta_1 = n_{air} \sin \theta_2$$

2) Set $\theta_2 = 90°$.

When no light is refracted, total internal reflection is occurring. The critical angle is the angle at which light experiences total internal reflection. That is when θ_2 (the exit angle) is 90°. In this case, $\theta_1 = \theta_{critical}$. Solve for n_{liquid}.

$$n_{liquid} \sin \theta_1 = n_{air} \sin \theta_2$$
$$n_{liquid} \sin \theta_{critical} = n_{air}$$
$$n_{liquid} = \frac{n_{air}}{\sin \theta_{critical}}$$

3) Plug in values.

The index of refraction of air is almost 1. Because the critical angle is less than 90°, the sine of the critical angle will be less than 1. Any number divided by a number less than 1 will lead to a larger result.

$$n_{liquid} = \frac{n_{air}}{\sin \theta_{critical}}$$
$$n_{liquid} = \frac{1}{\sin 51°}$$
$$n_{liquid} = 1.29$$

Similar Questions

1) A light ray is incident on crown glass ($n = 1.52$) at an angle of 30° to the normal. It is incident from air. What is the angle of refraction?
2) What is the critical angle for a diamond ($n = 2.42$) to air boundary?
3) A light ray passes from air into an unknown substance. The incident angle is 23°, and the refracted angle is 14°. What is the index of refraction of the unknown substance?