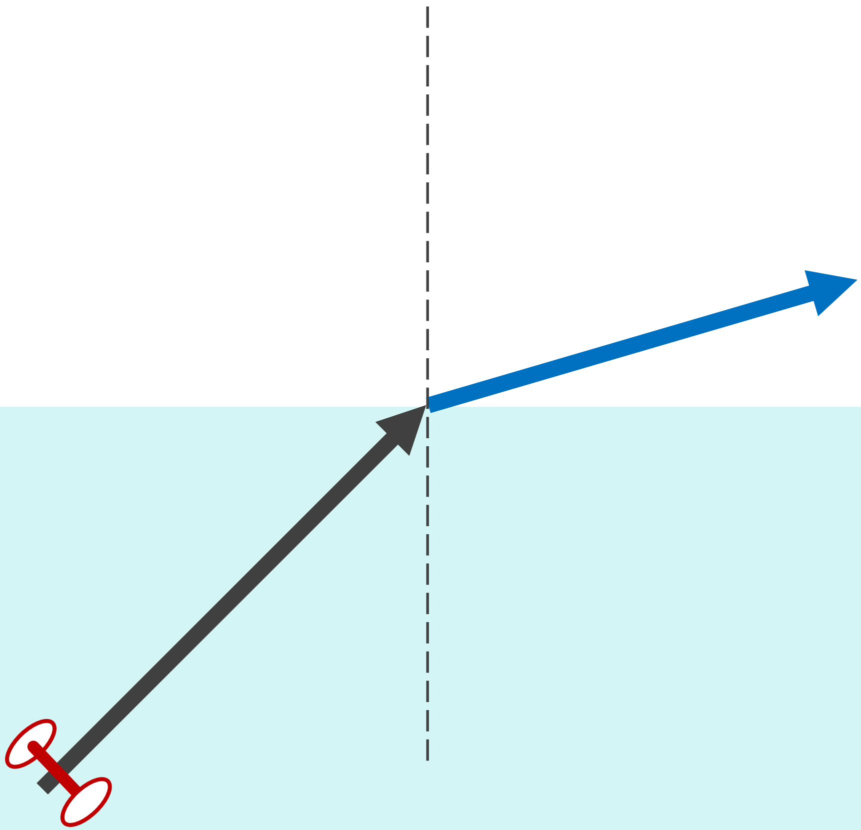
# Snell's Law & Critical Angle

IB PHYSICS | WAVES - LIGHT

# Remember the Bend



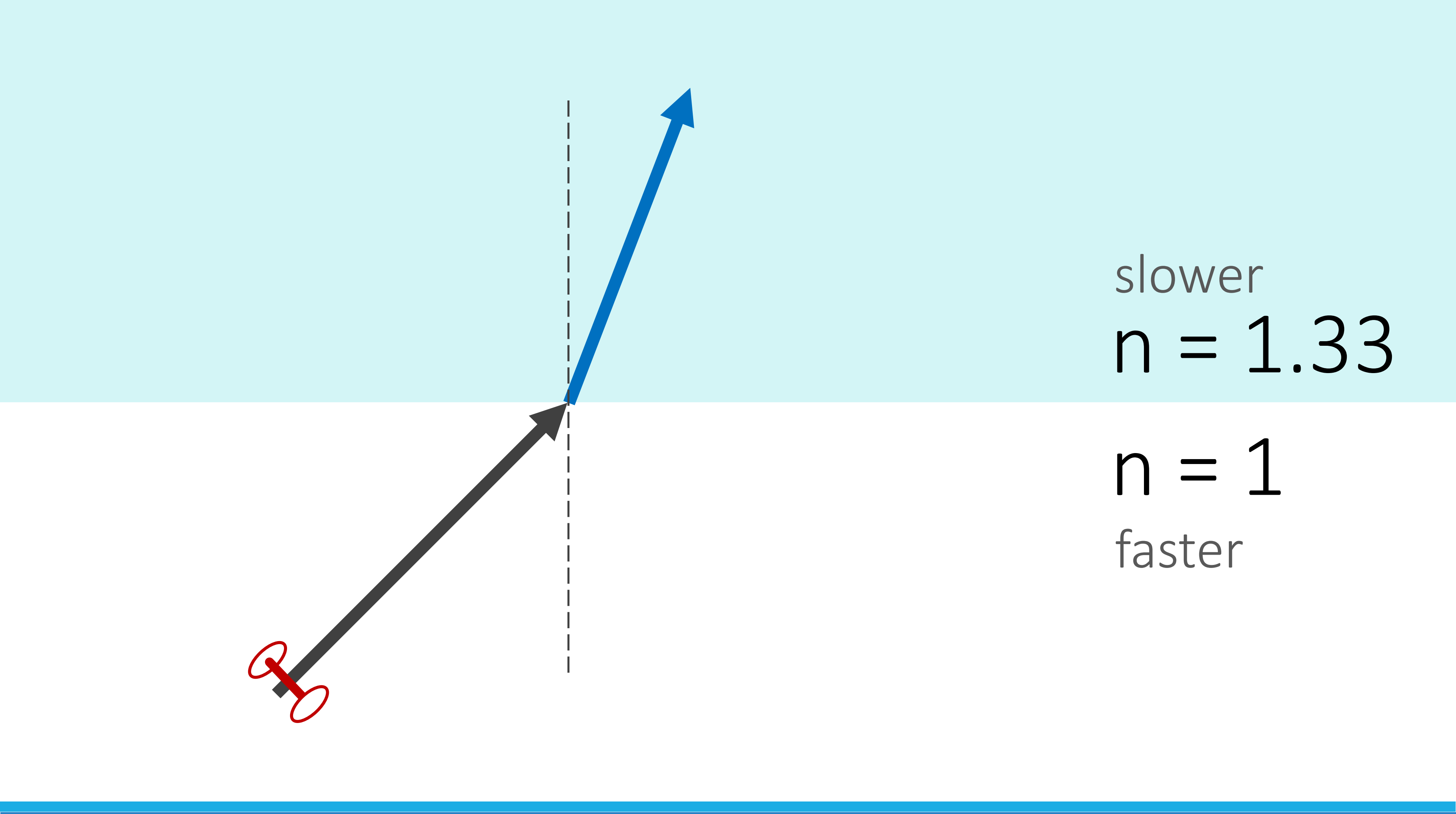
faster

n = 1

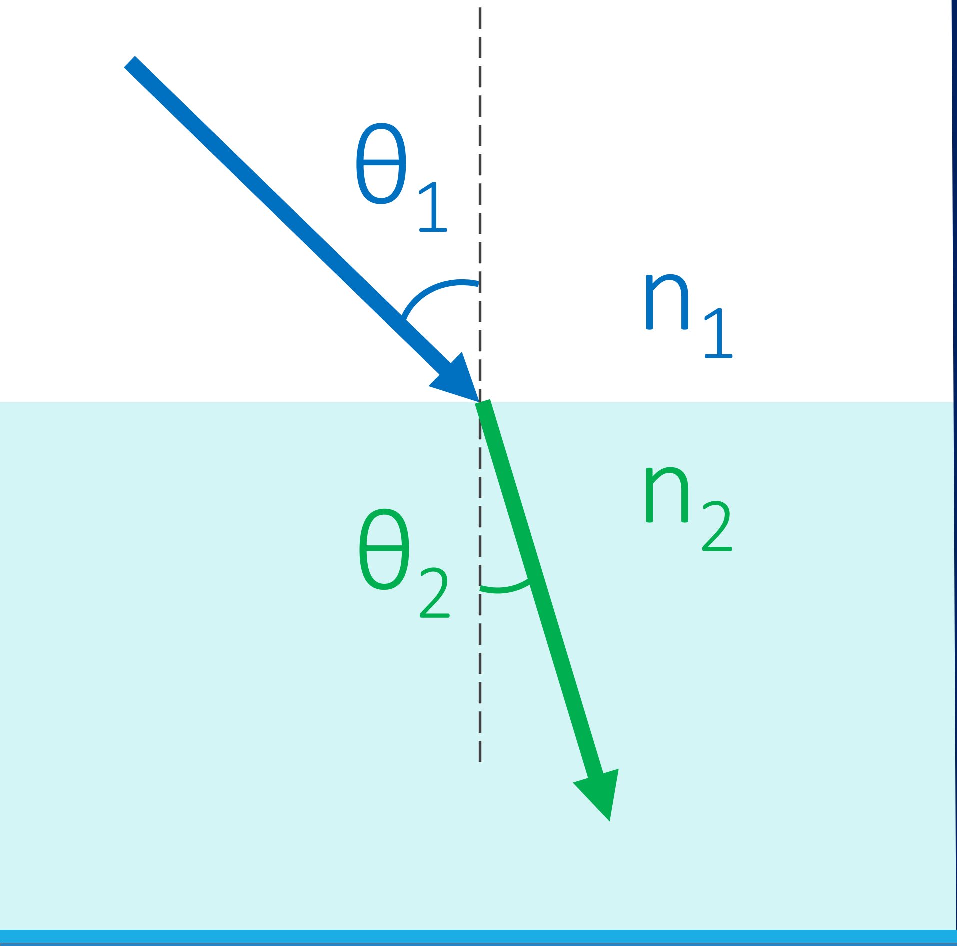
n = 1.33

slower

# Remember the Bend



# Snell's Law




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

# IB Physics Data Booklet

| Sub-topic 4.1 – Oscillations | Sub-topic 4.4 – Wave behaviour |
|---|---|
| $T = \frac{1}{f}$ | $\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{v_2}{v_1}$ |
| **Sub-topic 4.2 – Travelling waves** | $s = \frac{\lambda D}{d}$ |
| $c = f\lambda$ | Constructive interference: path difference $= n\lambda$ |
| **Sub-topic 4.3 – Wave characteristics** | Destructive interference: path difference $= (n + \frac{1}{2})\lambda$ |
| $I \propto A^2$<br>$I \propto x^{-2}$<br>$I = I_0 cos^2\,\theta$ | |

$$\frac{n_1}{n_2} = \frac{v_2}{v_1}$$

$$\frac{n_1}{n_2} = \frac{sin\theta_2}{sin\theta_1} = \frac{v_2}{v_1}$$

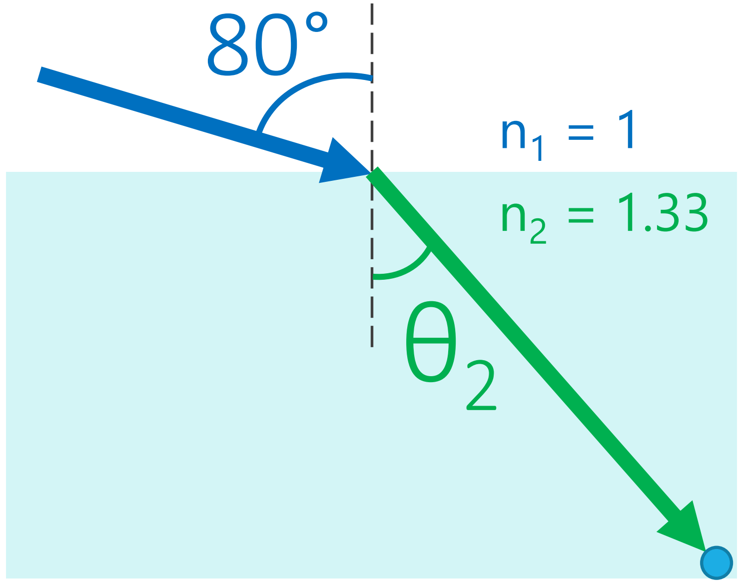
$$\frac{n_1}{n_2} = \frac{sin\theta_2}{sin\theta_1}$$

# Using Snell's Law

While aiming at a marble at the bottom of a fish tank filled with water ($n_2$ = 1.33), you point so that you can measure the angle of your incident rays. What is the angle of refraction?

$$\frac{n_1}{n_2} = \frac{sin\theta_2}{sin\theta_1} = \frac{v_2}{v_1}$$

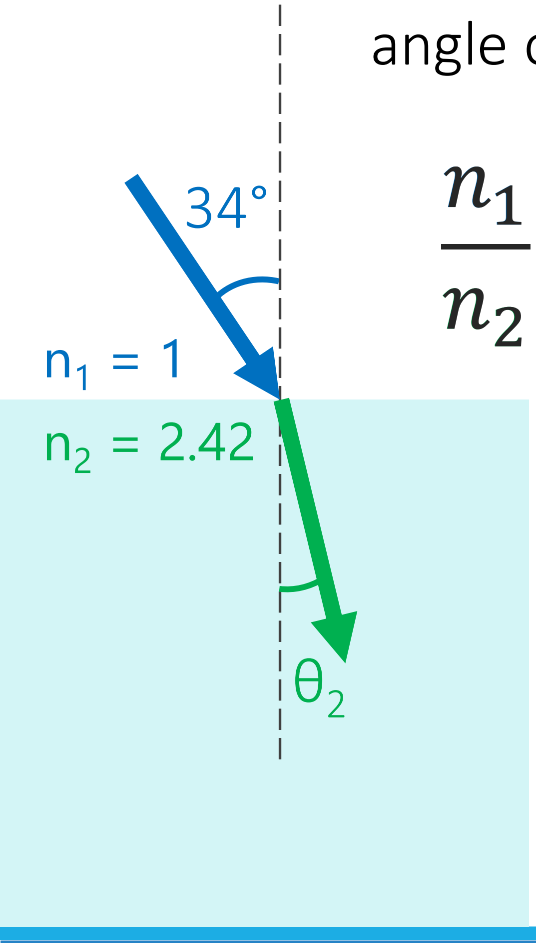
$$\theta_2 = sin^{-1}\left(\frac{n_1 sin\theta_1}{n_2}\right)$$




*Where does it "appear" the marble is?*

$$\theta_2 = sin^{-1}\left(\frac{1\sin(80°)}{1.33}\right) = \mathbf{47.8°}$$

# Try this...

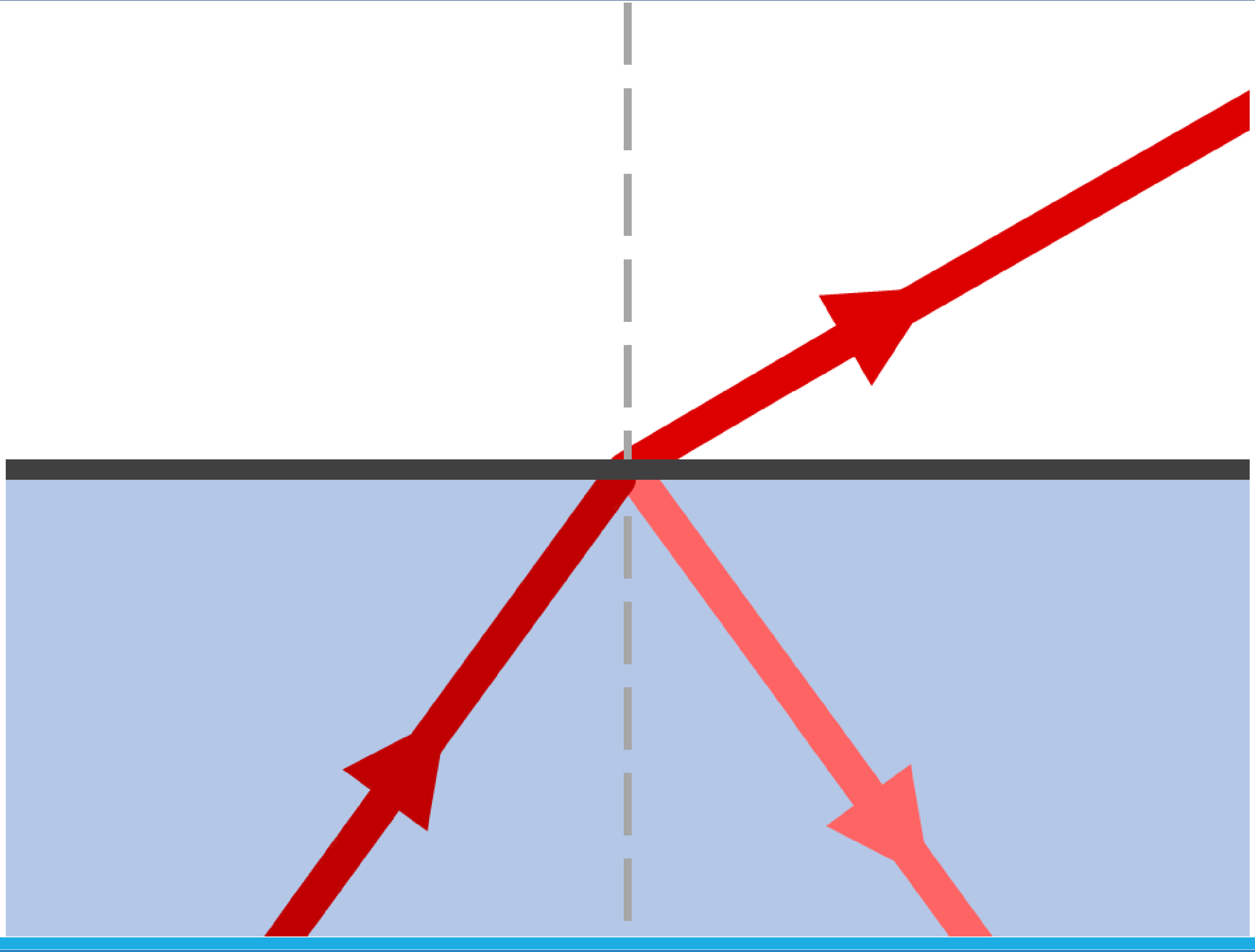



If the light travels from air to diamond (n = 2.42) at an angle of incidence of 34°, find the angle of refraction.

$$\frac{n_1}{n_2} = \frac{sin\theta_2}{sin\theta_1} = \frac{v_2}{v_1} \qquad \theta_2 = sin^{-1}\left(\frac{n_1 sin\theta_1}{n_2}\right)$$

$$\theta_2 = sin^{-1}\left(\frac{1\sin(34°)}{1.33}\right) = \mathbf{13.4°}$$

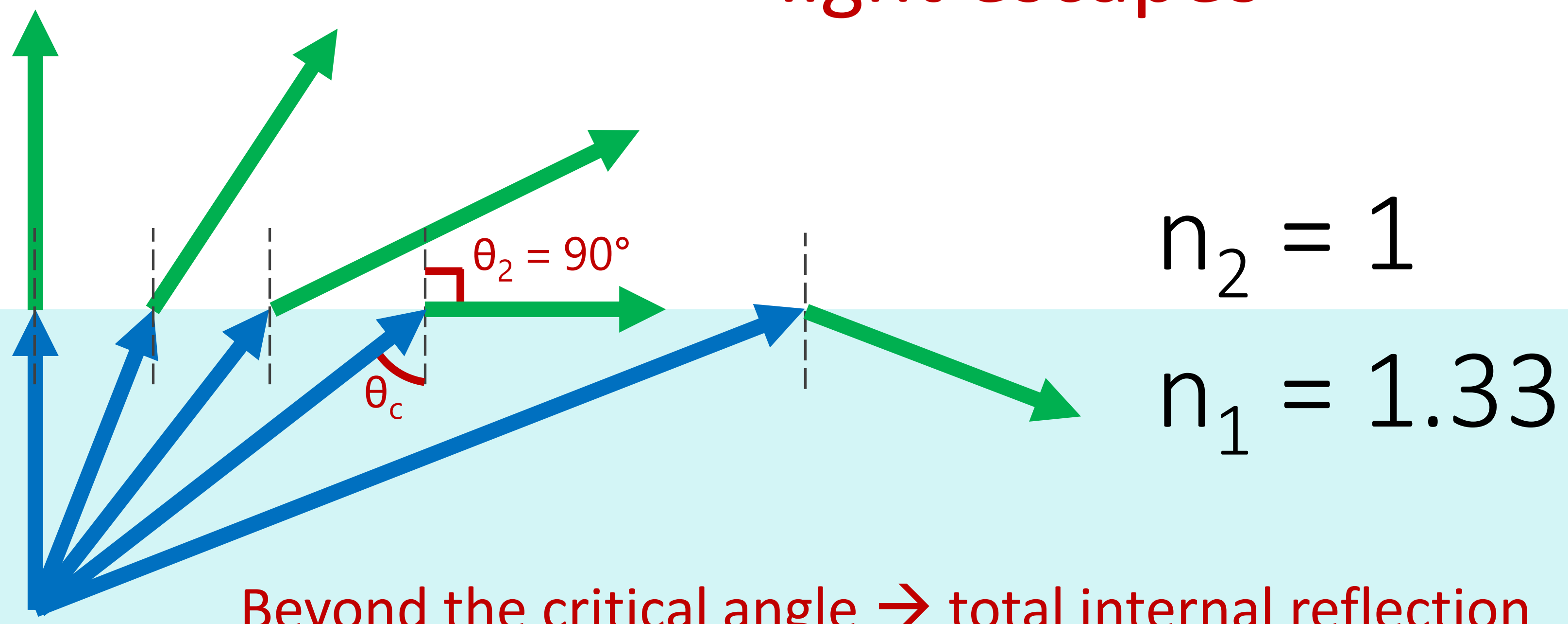
# Refraction AND Reflection



# Critical Angle

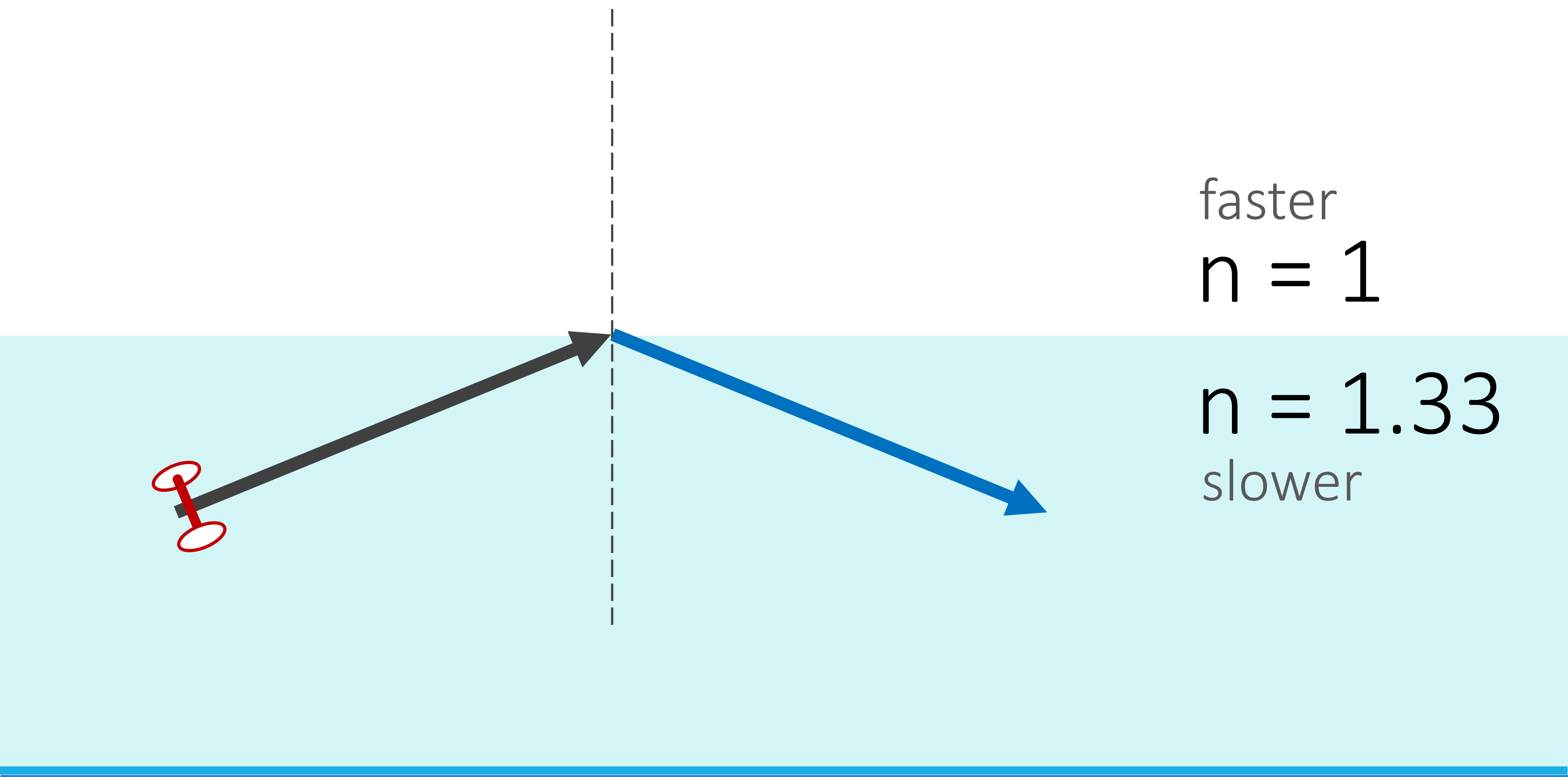
Critical Angle: $\theta_c$

Angle at which $\theta_2 = 90°$ so no light escapes




Beyond the critical angle → total internal reflection

# Remember the Bend

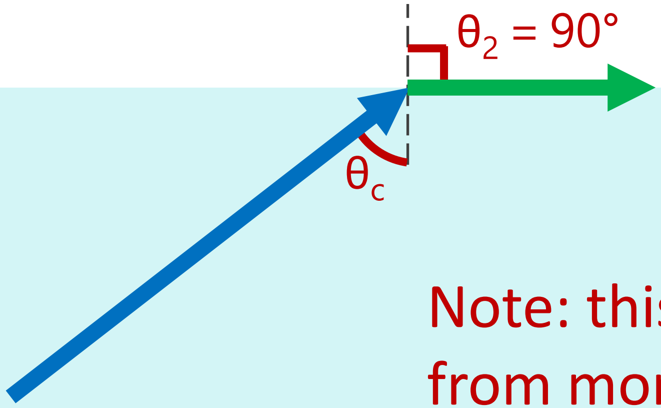


# Critical Angle

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

$$\theta_1 = sin^{-1}\left(\frac{n_2 sin\theta_2}{n_1}\right)$$

$$\theta_c = sin^{-1}\left(\frac{n_2 \mathbf{sin(90°)}}{n_1}\right) = sin^{-1}\left(\frac{n_2}{n_1}\right)$$




$n_2 = 1$

$n_1 = 1.33$

Note: this only happens when transitioning from more dense to less dense

# Try This

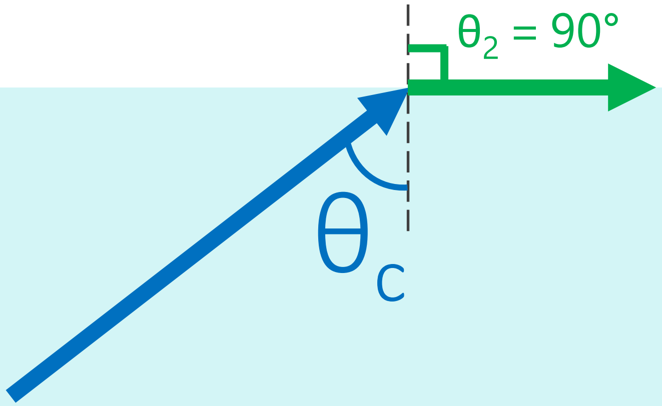
What’s the critical angle between glass and air?

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

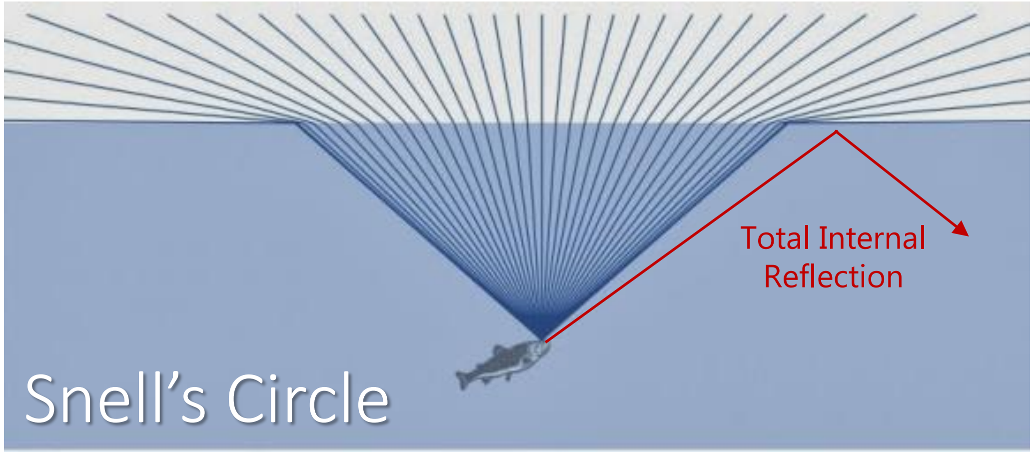
$$\theta_c = \sin^{-1}\left(\frac{1}{1.52}\right) = \mathbf{41.1°}$$

$n_2 = 1$

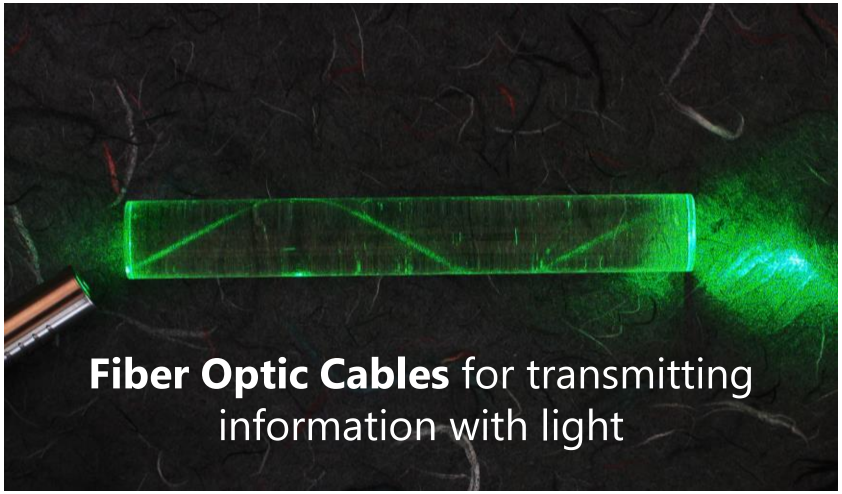
$n_1 = 1.52$

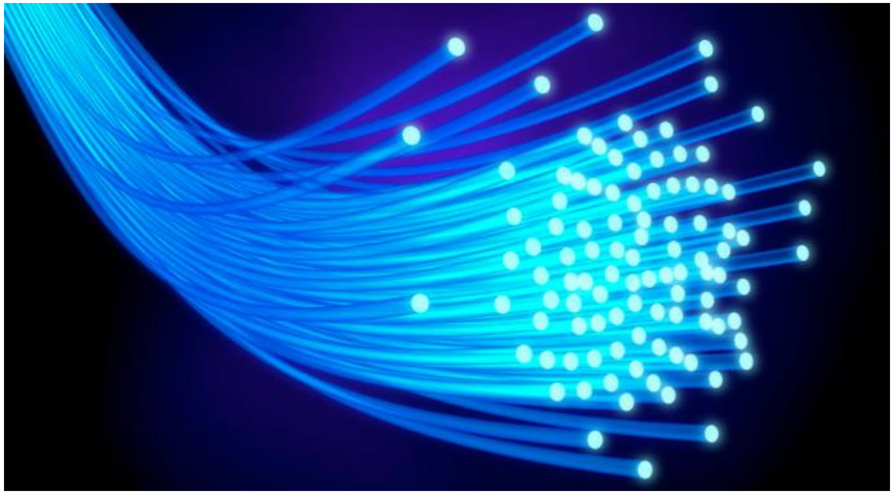


# Why does it matter?



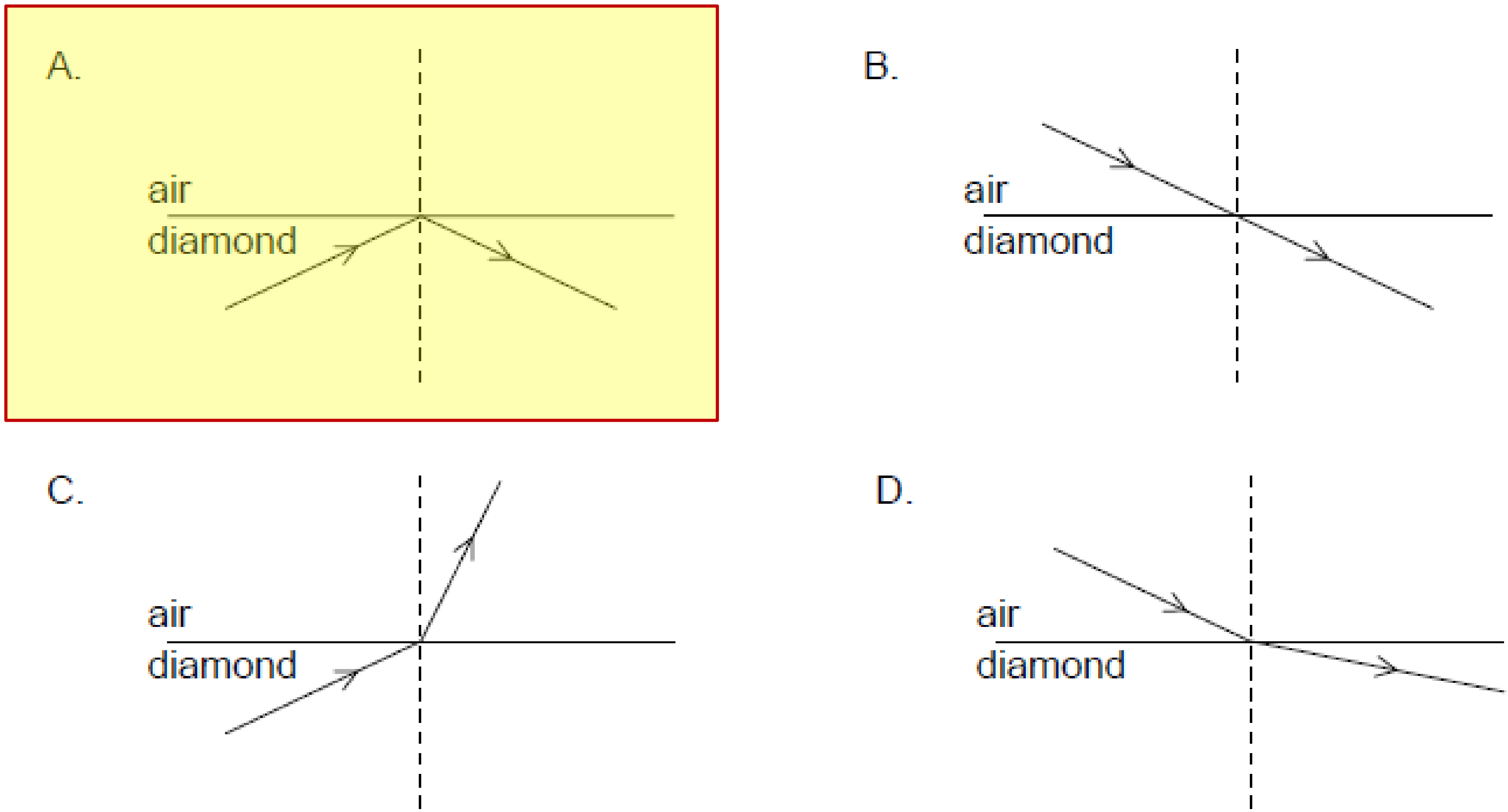




# Sample IB Question

A light ray is incident on an air–diamond boundary. The refractive index of diamond is greater than 1. Which diagram shows the correct path of the light ray?



# Lesson Takeaways

- ❑ I can mathematically relate the angles of refraction to the indices of refraction for the materials
- ❑ I can describe the phenomenon of total internal reflection
- ❑ I can calculate the critical angle of incidence so that the light cannot escape the medium