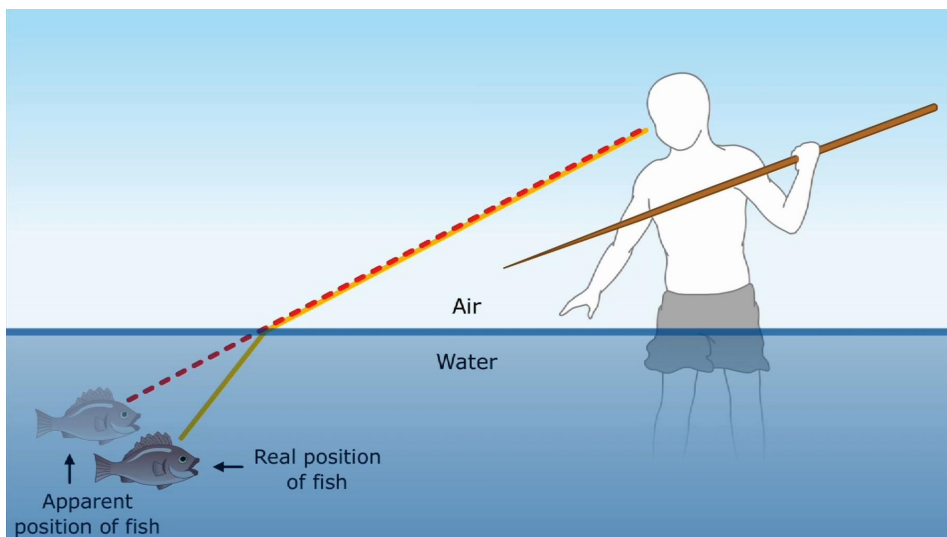


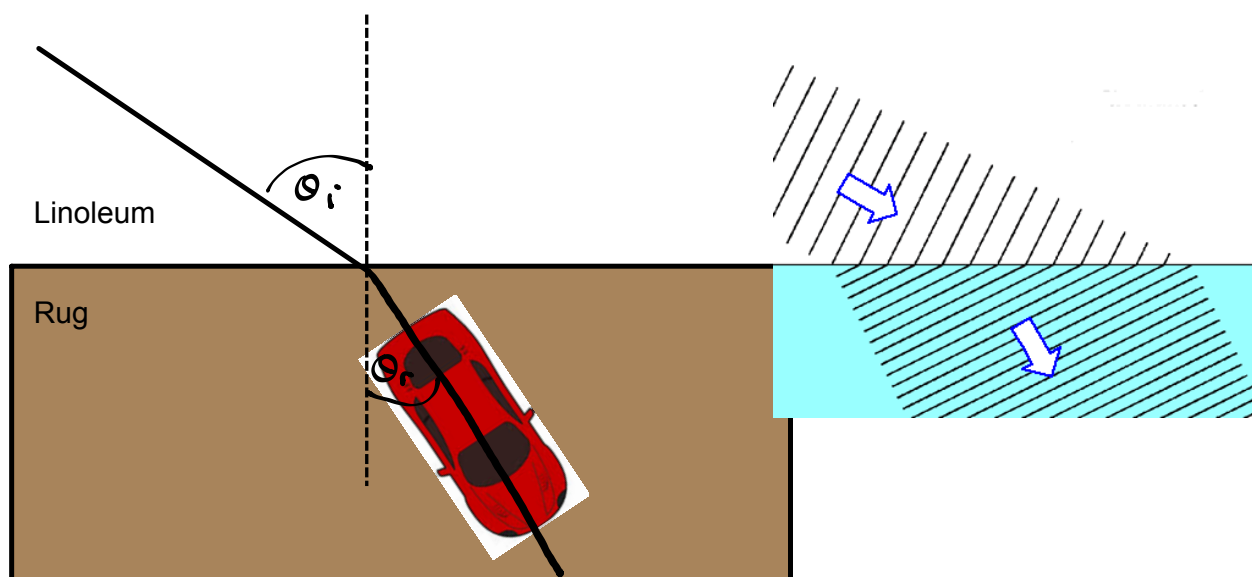
L05 - Refraction and Snell's Law

Demos:

- Pyrex rod and vegetable oil
- Spiral glass tube with laser
- Colorado PhET demo
- Prism and light



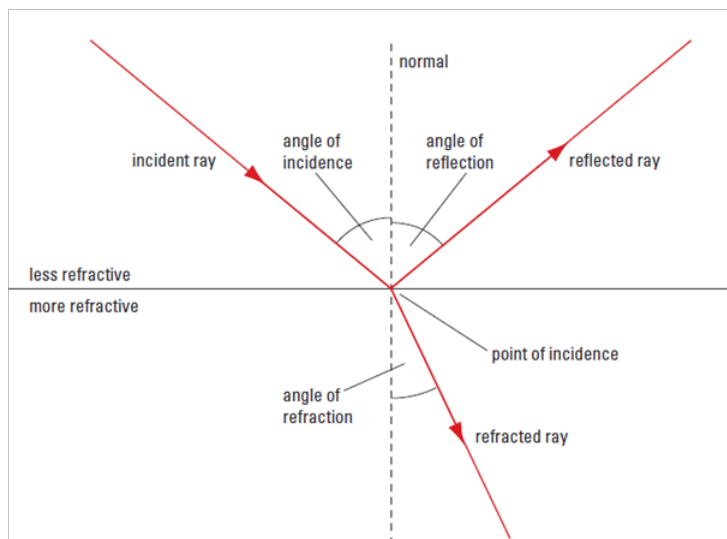
Snell's Law with Toy Cars



Snell's Law

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

Colorado PhET Simulation



- Refractive Index (n) – a ratio comparing the speed of light in a vacuum compared to the speed of light in a given material $n = c/v$. P. 667 for a list.

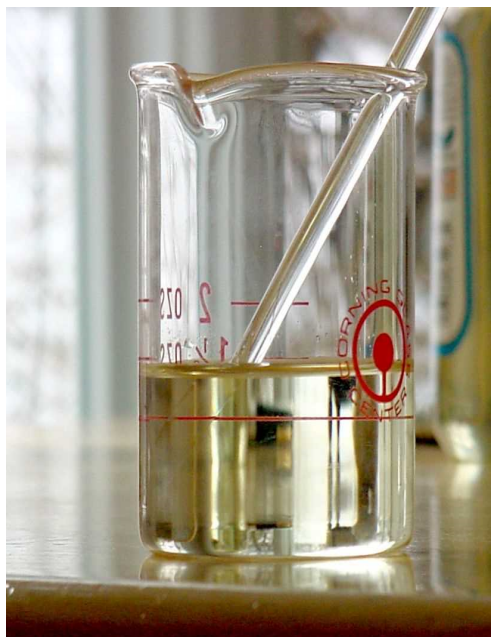
Large n = Light travels slower

Small n = Light travels faster

When $n = 1$, $c = 3.0 \times 10^8$ m/s (speed of light in a vacuum)

Demo

Pyrex stirring rod in olive or vegetable oil.



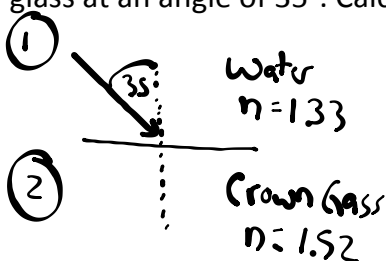
Pg 667 - Needed for most textbook questions; Given on exams.

▼ **Table 13.4** Absolute Refractive Indexes
(for Sodium Yellow Light, $\lambda = 589 \text{ nm}$)

Medium	Index of Refraction
vacuum	1.0000
air	1.0003
ice	1.31
water	1.33
ethanol	1.37
glycerin	1.47
quartz glass	1.47
crown glass	1.52
light flint glass	1.58
Lucite (plexiglass)	1.52
ruby	1.54
zircon	1.92
diamond	2.42

Given on formula sheet as $n = 1.00$

Q1: Yellow light travels from water into crown glass. The light rays are incident on the crown glass at an angle of 35° . Calculate the angle of refraction as the light enters the crown glass.



$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

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

$$\frac{\sin 35^\circ}{\sin \theta_2} = \frac{1.52}{1.33}$$

$$\sin \theta_2 = 0.50187\dots$$

$$\boxed{\theta_2 = 30.1^\circ}$$

Q2: A ray of yellow light with a wavelength of 570 nm travels from air into diamond at an angle of incidence of 30° . Determine the speed of light in the diamond.

$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

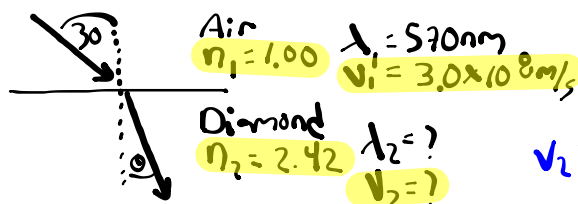


Table 13.4 Absolute Refractive Indexes (for Sodium Yellow Light, $\lambda = 589 \text{ nm}$)

Medium	Index of Refraction
vacuum	1.0000
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water	1.33
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light flint glass	1.58
Lucite (plexiglass)	1.52
ruby	1.54
zircon	1.92
diamond	2.42

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

$$\frac{2.42}{1.00} = \frac{3.0 \times 10^8}{v_2}$$

$$v_2 = 1.24 \times 10^8 \text{ m/s}$$

Q3: Determine the wavelength of the light as it travels in the diamond.

$$\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$$

$$\frac{2.42}{1.00} = \frac{570 \text{ nm}}{\lambda_2}$$

$$\lambda_2 = 235.537 \text{ nm} \approx 236 \text{ nm}$$

$$\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

$$\frac{3.00 \times 10^8}{1.2396942 \times 10^8} = \frac{570}{\lambda_2}$$

$$\lambda_2 = 235.537 \dots \approx 236 \text{ nm}$$

$$\frac{3.00 \times 10^8}{1.24 \times 10^8} = \frac{570}{\lambda_2}$$

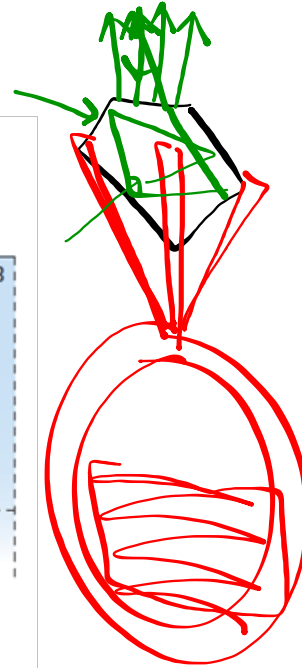
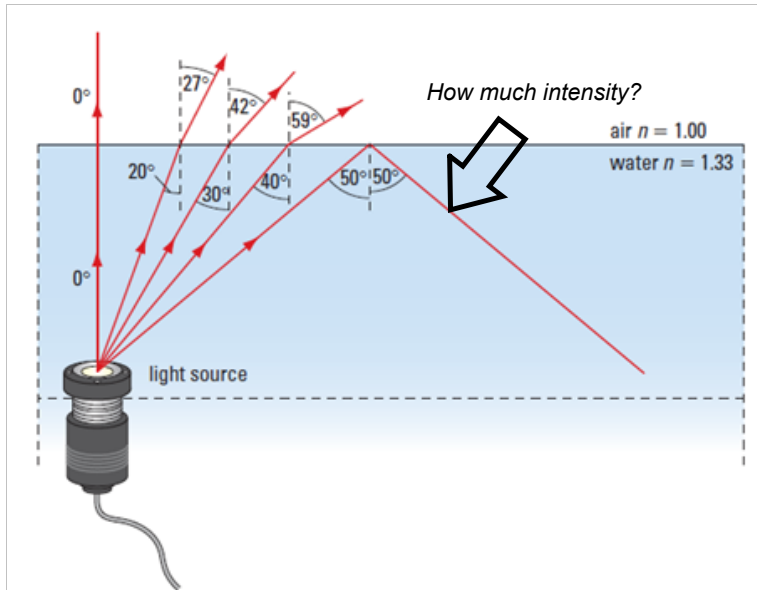
$$\lambda_2 = 235.6 \approx 236 \text{ nm}$$

Total Internal Reflection

Total Internal Reflection

- Critical angle: The angle of incidence where the refracted angle is 90° .
- Occurs when light goes from a high index substance into a lower index substance.

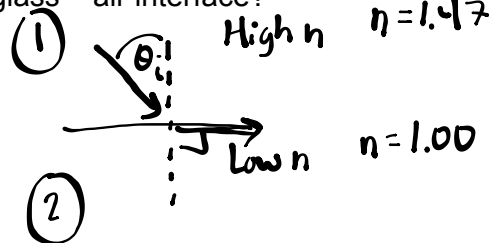
Colorado PhET Simulation



Q4: What is the critical angle for the quartz glass – air interface?

▼ **Table 13.4** Absolute Refractive Indexes
(for Sodium Yellow Light, $\lambda = 589 \text{ nm}$)

Medium	Index of Refraction
vacuum	1.0000
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crown glass	1.52
light flint glass	1.58
Lucite (plexiglass)	1.52
ruby	1.54
zircon	1.92
diamond	2.42



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

$$\frac{\sin \theta}{\sin 90} = \frac{1.00}{1.47}$$

$$\sin \theta = 0.68027$$

$$\theta = 42.9^\circ$$

Total Internal Reflection and Fiber Optic Cables

- Demo:**
- Spiral glass tube with laser

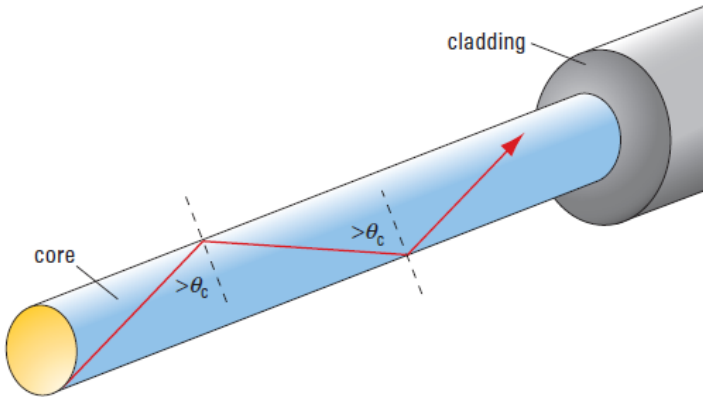
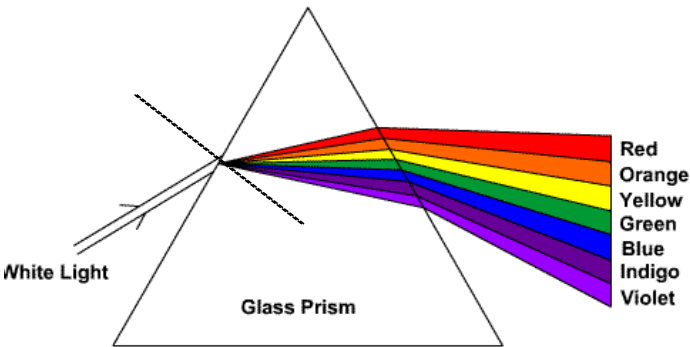
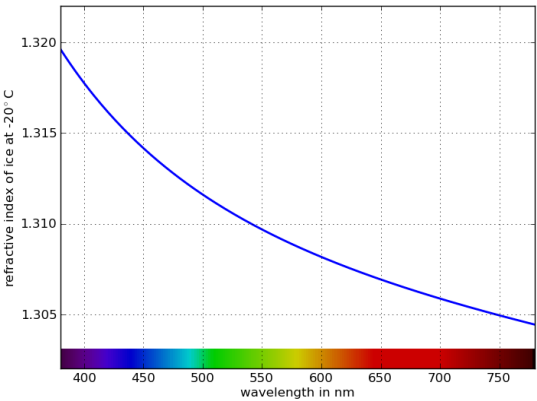


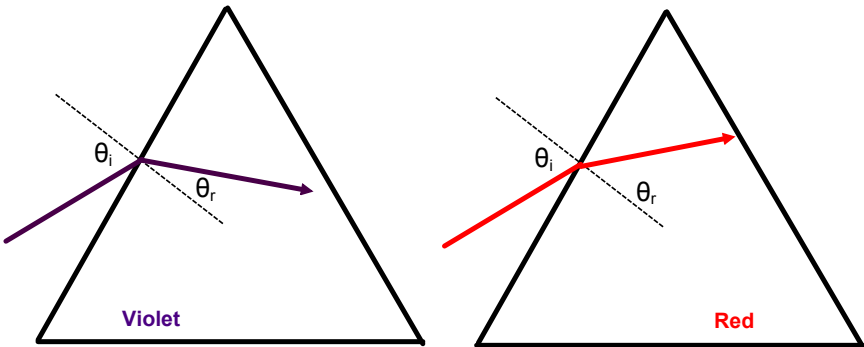
Figure 13.51 An optical fibre showing cladding, core, axis, and critical angle

Dispersion - Index of Refraction for Different Wavelengths



Which color bends more?

Colorado PhET Simulation



Blue Bends Better