

Lecture 39

Microscopic Point-of-View:

- Interaction between EM waves and the medium
 - Specifically; with electrons in the medium:
- Resultant electric fields are complex
 - original field, radiation field, re-radiation field...

$$a = \frac{Ee}{m_e}$$

Macroscopic Description

- Light wave + Wave front
- Light particles (photons) speed in medium: $v = \frac{c}{n}$
 - n = index of refraction
- Wavefront
 - $f = f'$ (determined by oscillating frequency of original source)

$$\lambda' = \frac{v}{f} = \frac{c}{f} \frac{1}{n} = \frac{\lambda}{n}$$

Refraction Phenomena

Snell's Law:

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

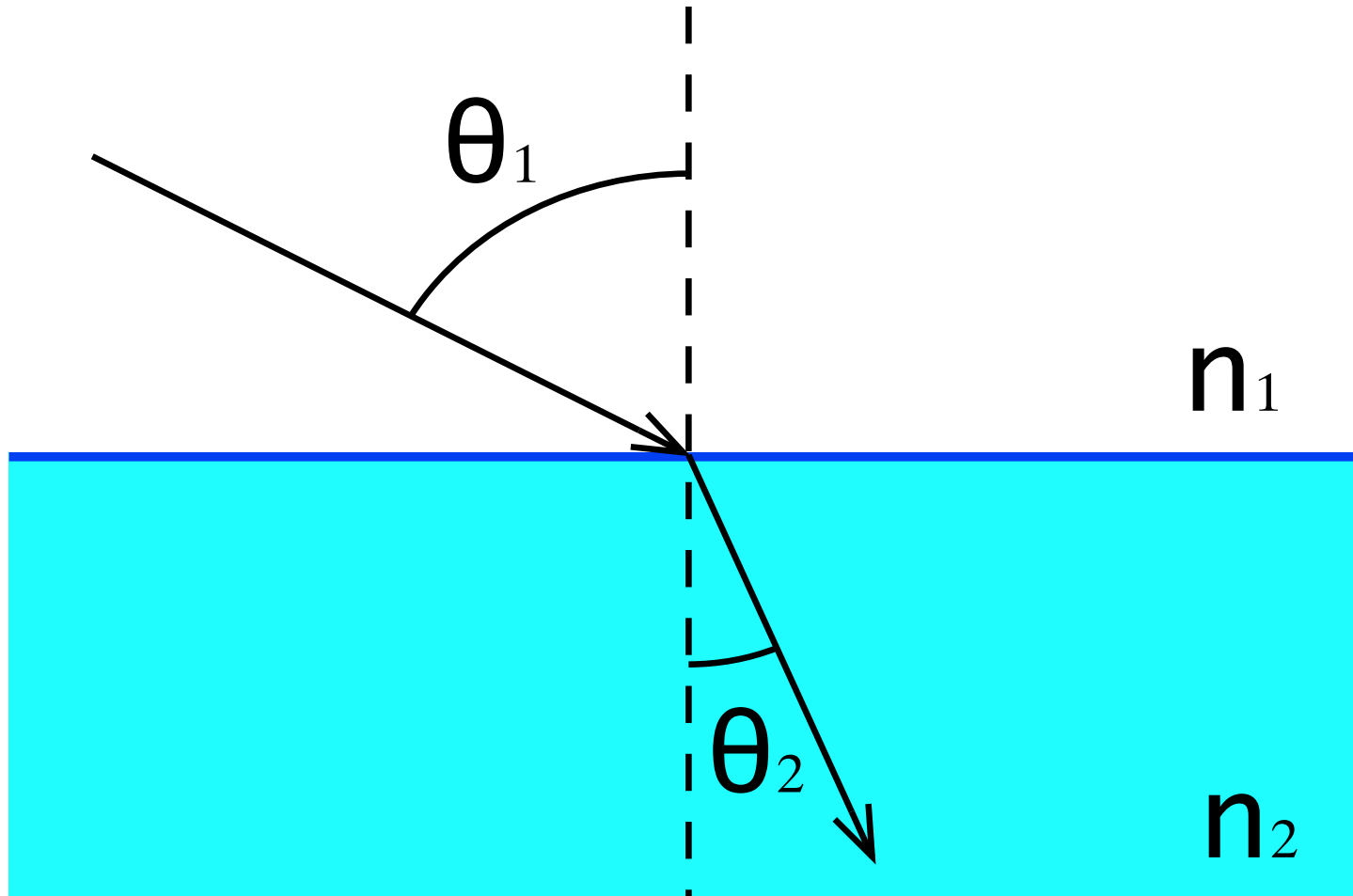
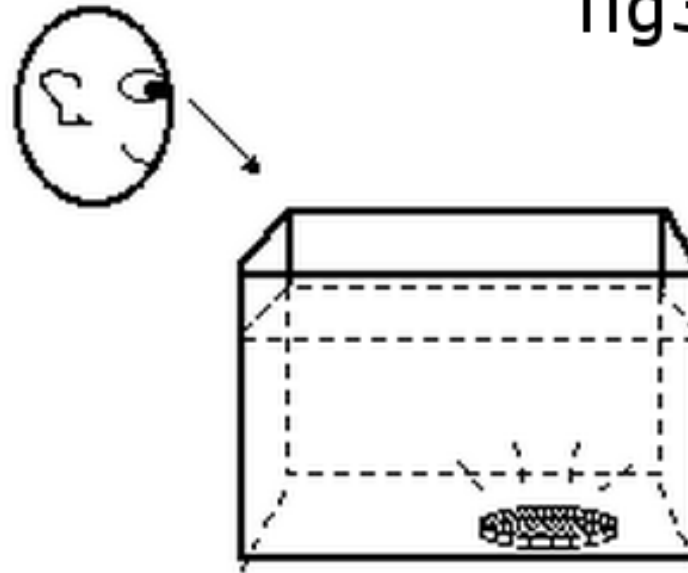


fig38.1c



A coin under water appears to be:

Choice	Appearance
1	Nearer to the surface than it really is
2	Farther from the surface than it really is
3	As deep as it really is

Hint: Answer this question based on your daily experience. Can you confirm your answer using Snell's law? The index of refraction for air is ~ 1 and for water is ~ 1.33 .

Clicker Question Explanation

- from IQ Library
- I.Q. 36.1c

Explanation:

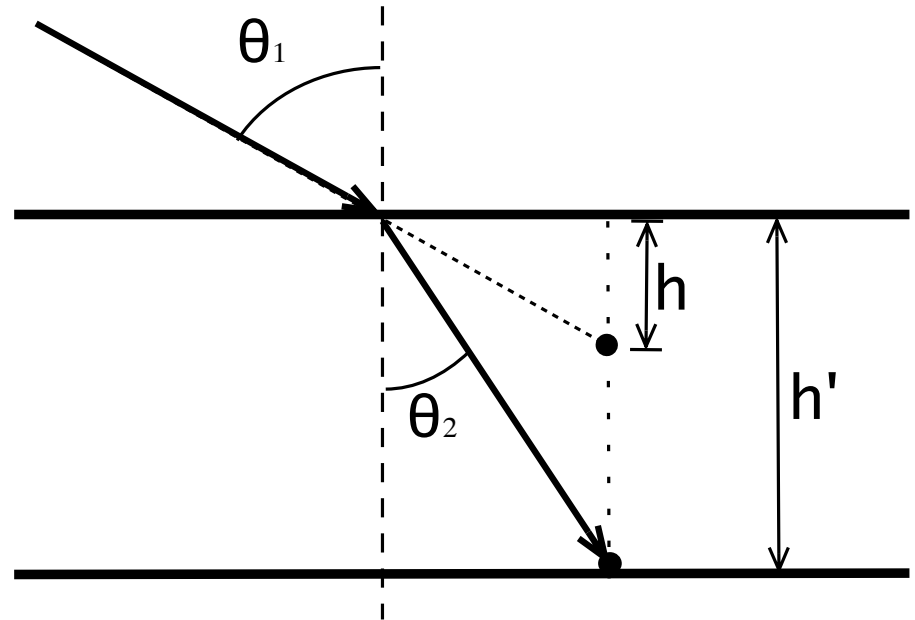
$$n_1 = 1$$

$$n_2 = n \times 1.33$$

Small angle approximation

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

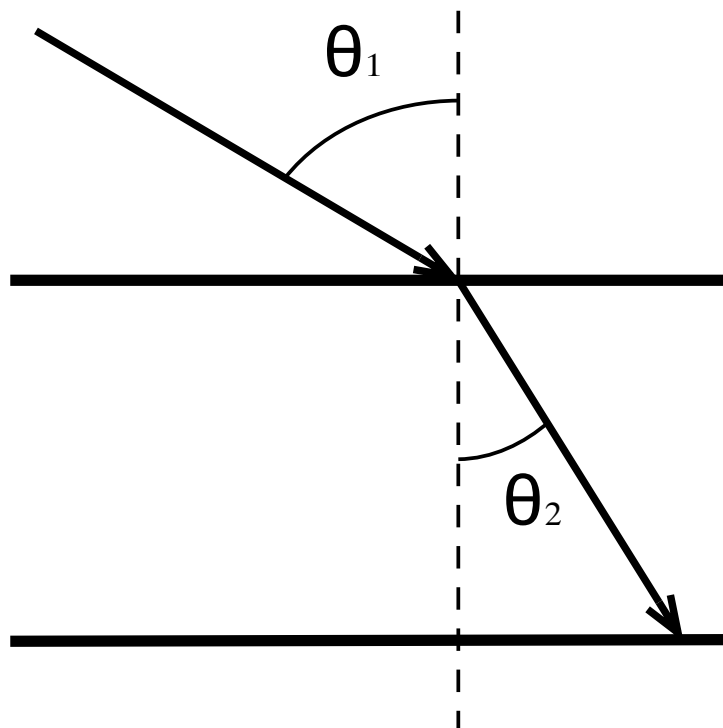
$$n_1 \theta_1 \approx n_2 \theta_2$$



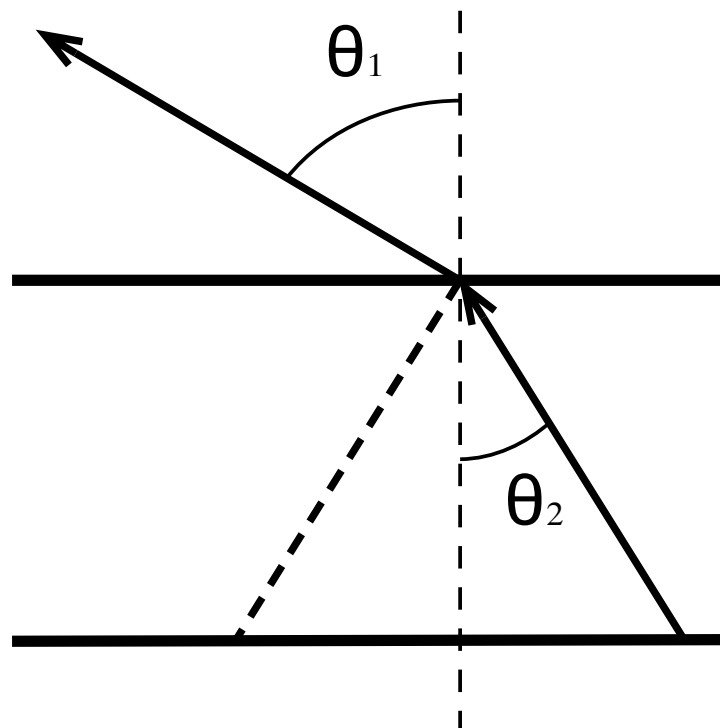
$$\frac{\theta c}{h} \approx n \frac{\theta c}{g}$$

$$h' = \frac{h}{n}$$

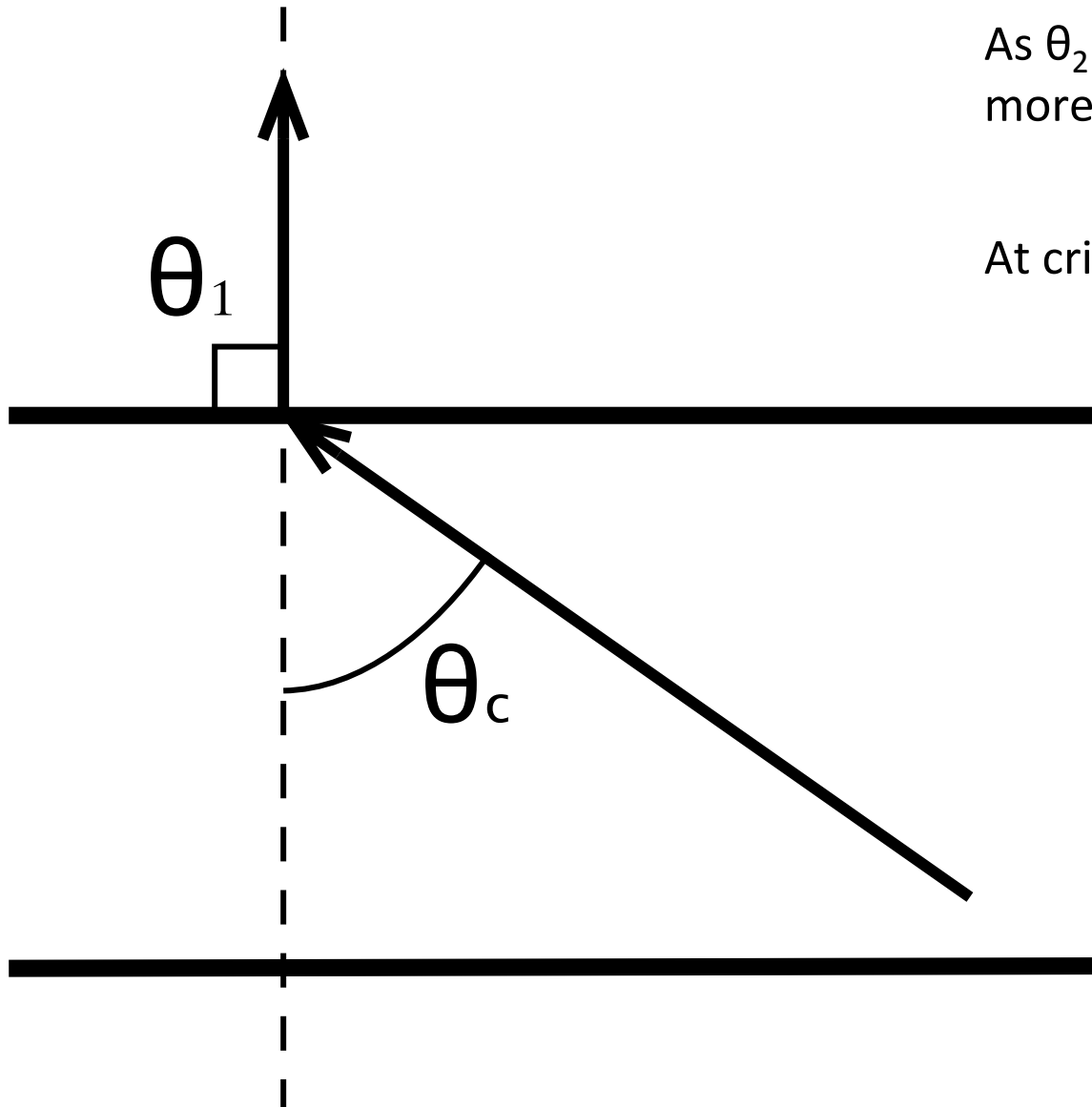
Total Reflection Region



Time Reversed Situation



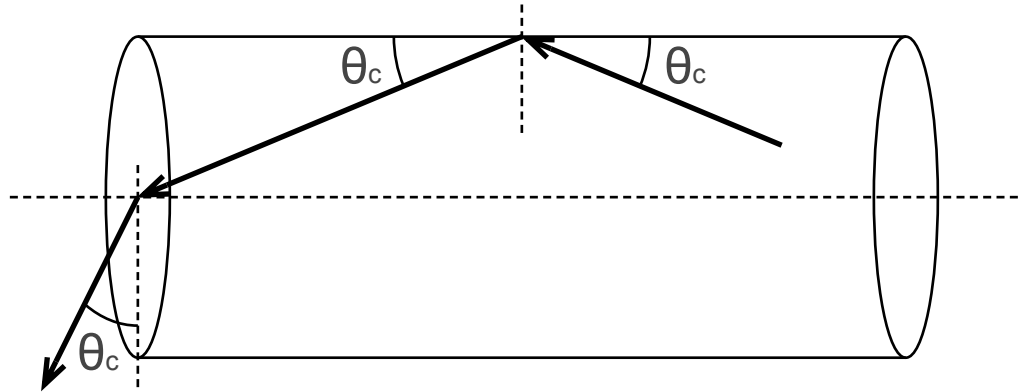
Reflection/Refraction Critical Angle



As θ_2 increases, θ_1 increases more rapidly

At critical angle, $\theta_2 = \theta_c$
 $\theta_1 = 90^\circ$

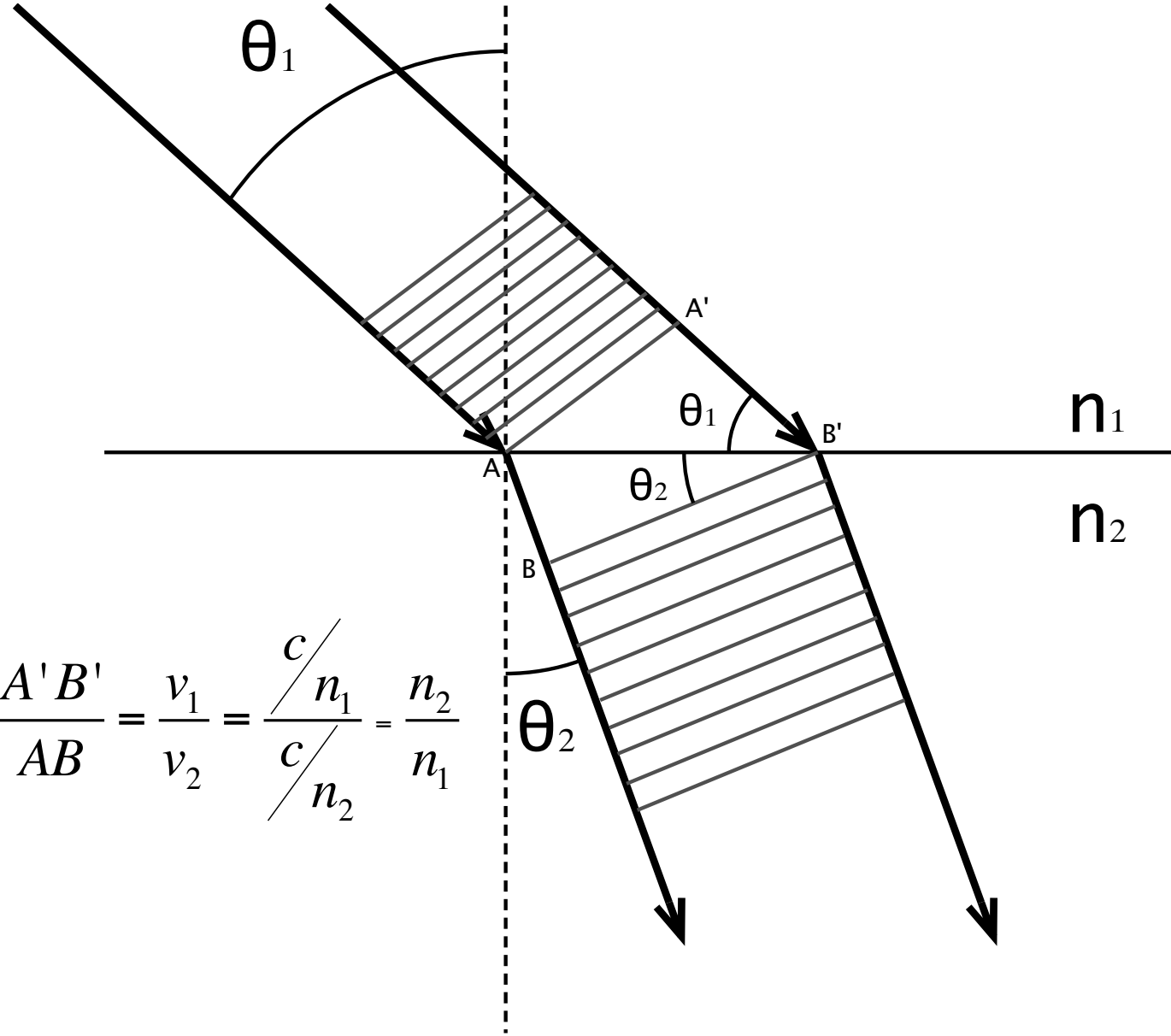
Application: Optical Fiber [Ch24.HW4.009]



$$\theta > \theta_c \quad \phi < \phi_c$$

$$\theta < \theta_c \quad \phi > \phi_c \quad \text{Total reflection region}$$

Derivation of Snell's Law



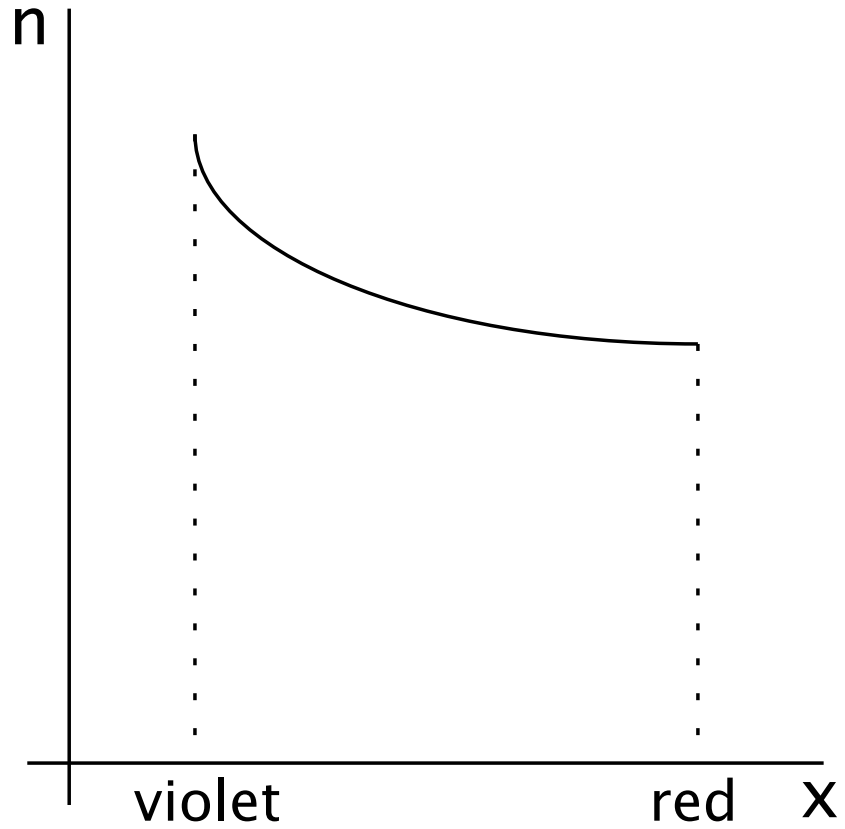
$$AB = v_1 t$$

$$A'B' = v_2 t$$

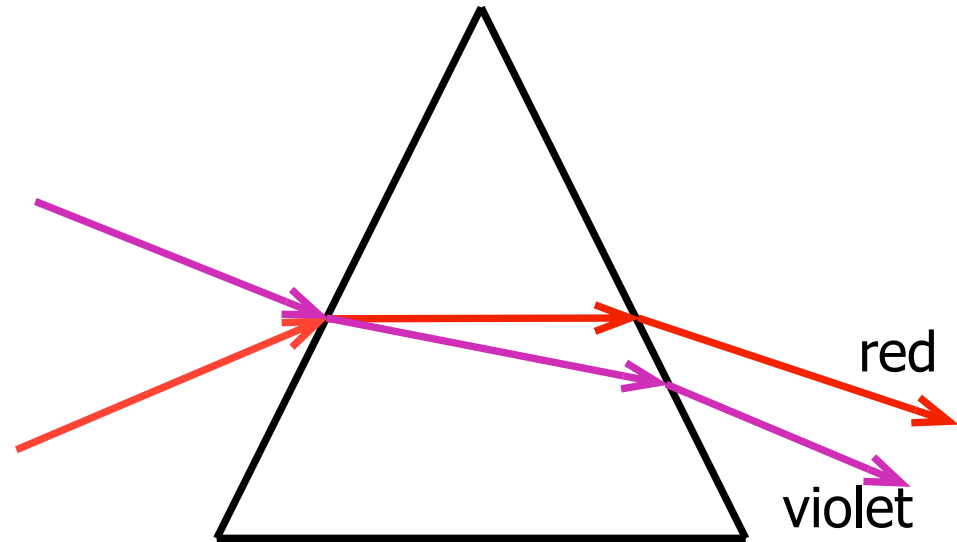
$$\frac{\sin \theta_1}{\sin \theta_2} = \frac{A'B' / AB'}{AB / AB'} = \frac{A'B'}{AB} = \frac{v_1}{v_2} = \frac{c/n_1}{c/n_2} = \frac{n_2}{n_1}$$

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

Prism



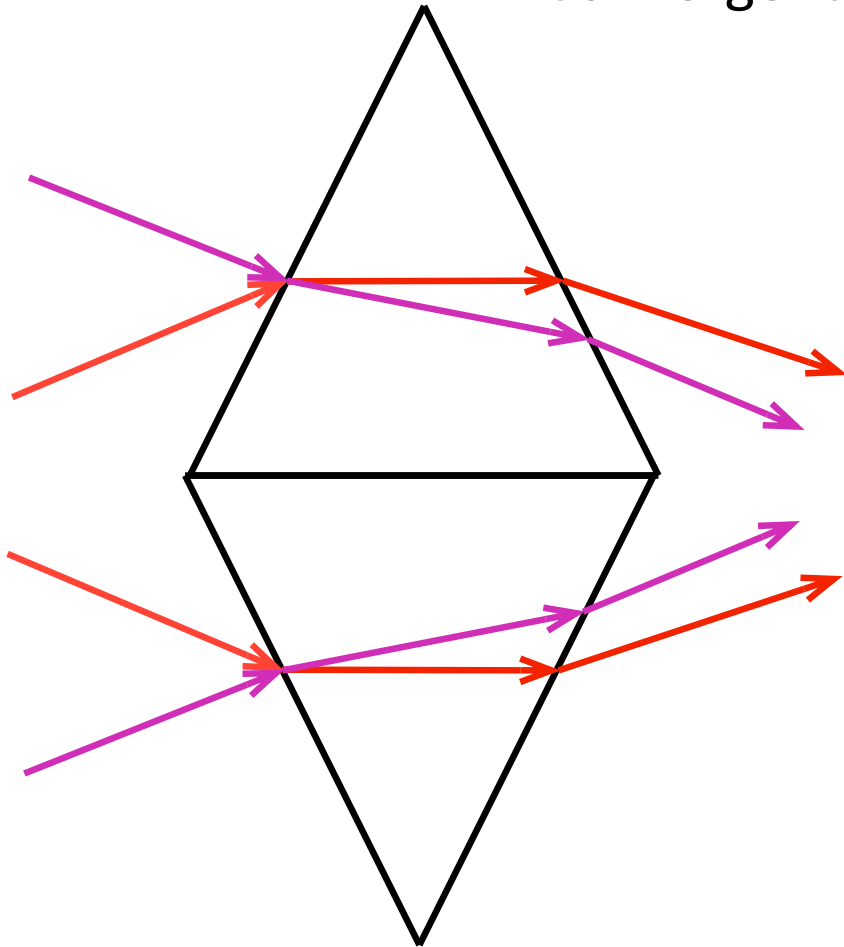
Color Dispersion



At each surface, the light ray is bending
Violet light has more bending than red

Two Prisms

Convergent



Divergent

