5. Will light slow down if it travels from corn oil to glycerol? Explain.

no - they have the same index

6. If light crosses a boundary between two substances with very different indices of refraction . . .

it will change speed (and therefor refract) a lot

7. If light crosses a boundary between two substances with very similar indices of refraction . .

it will not change speed or refract) much

8. Why does the table indicate $(f = 5.09 \times 10^{14}$ Hz)?

average frequency of visible light - each frequency has a slightly different index
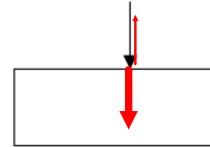

Complete the path of the light ray through the Glass block in each diagram below.
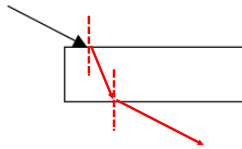
Rule for Refraction:

Low to High - bends toward normal

High to Low - bends away from normal

$$\frac{\sin\theta_{air}}{\sin\theta_{water}} = \frac{1.33}{1}$$
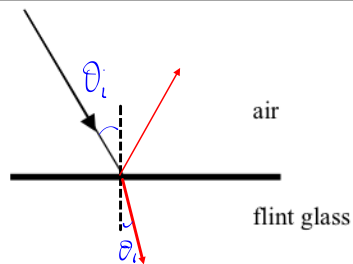
$$1 \cdot \sin\theta_{air} = 1.33 \cdot \sin\theta_{water}$$

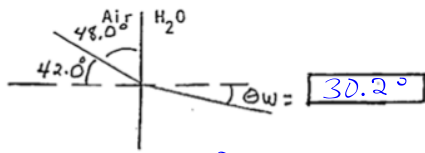## Snell's Law of Refraction

Snell's Law (Law of Refraction)

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

Use Snell's law to construct the refracted ray on the diagram at right.
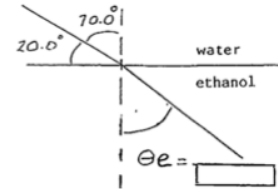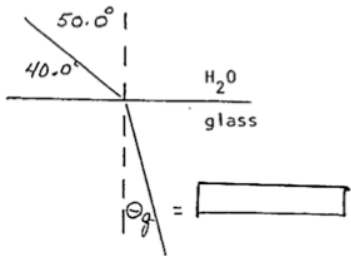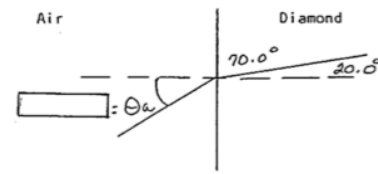
air

flint glass

θ_i

Use a protractor and Snell's law to determine and draw the path light takes in the material as shown.
Note: Indices are in the text. Also, not all interfaces are horizontal. Dotted lines are the normal lines.

Air | H_2O

48.0°

42.0°

$\theta w = \boxed{30.2°}$

Air   Diamond

70.0°   20.0

$: \theta_d$

$n_A \sin\theta_A = n_w \sin\theta_w$

$$\theta_w = \sin^{-1}\left(\frac{n_A}{n_w} \cdot \sin\theta_A\right) = \sin^{-1}\left(\frac{1}{1.33} \cdot \sin 42\right)$$

50.0°

40.0° H_2O

glass

$|\theta_g| = \boxed{}$

70.0°

20.0°   water

ethanol

$|\theta_e = \boxed{}$

Refraction and Wavelength
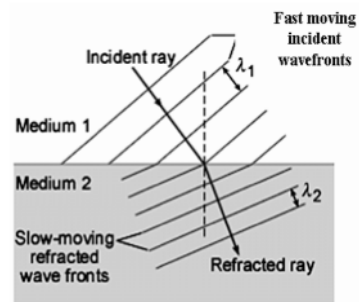
Why does refraction occur?

Because one part of the incident wave changes speed before the rest of the wave

As the wave enters a more optically dense medium . . .

Wavelength decreases, speed decreases, frequency remains the same, period and phase remain the same

Fast moving incident wavefronts

Incident ray

λ_1

Medium 1

Medium 2

Slow-moving refracted wave fronts

λ_2
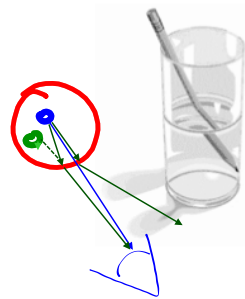
Refracted ray

Relationship:

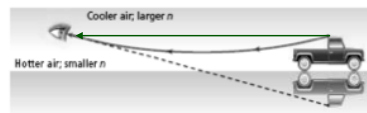$$\frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

A beam of monochromatic yellow light with a frequency of 5.09 x 10^{14} Hz enters a block of diamond from air.

a) What is the frequency of the light in the diamond?

b) What is the wavelength of the light in air?

c) What is the wavelength of the light in the diamond?
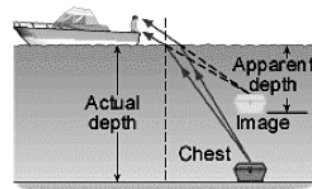
d) What is the speed of the light in the diamond?
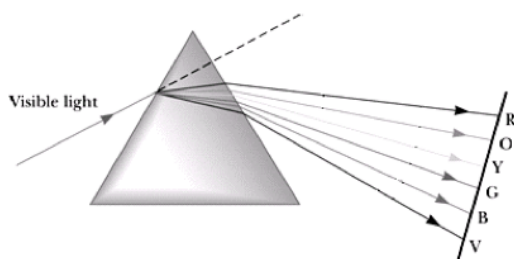

Optical Effects due to Refraction

	Mirages	**Apparent Depth**

Cooler air; larger n

Hotter air; smaller n

Actual depth / Apparent depth / Image / Chest

Dispersion: the separating of white light into its component colors due to refraction

Visible light

R O Y G B V

© 2003 Thomson - Brooks Cole

Red:

bends least

Violet:

bends most

Explanation:

range of indices of refraction for different colors

Dispersion Rule:
RED RESISTS REFRACTION

Rainbows Caused by Dispersion

Rainbows are due to sunlight from over an observer's shoulder being refracted by water droplets in the air. Each color is refracted by a different amount with the result being the dispersion of the light into its component colors.

drop A

white light
from the sun

drop B

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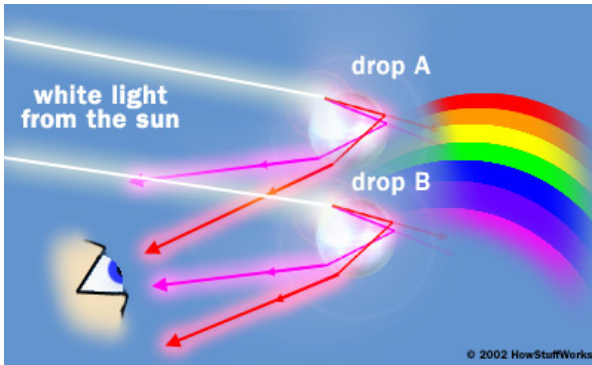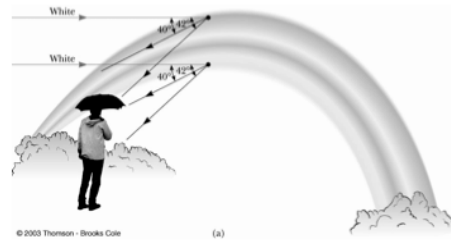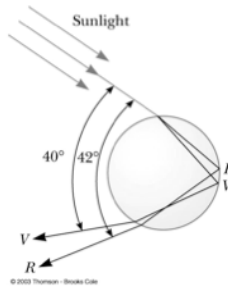
Total Internal Reflection

Total Internal Reflection: the complete reflection of light at a boundary – no refraction

Conditions for Total Internal Reflection:

1. ray of light must be traveling from the more optically dense to the less optically dense medium

2. ray must strike the boundary at an angle greater than the critical angle

Low index of refraction, n_2

Higher index of refraction, n_1
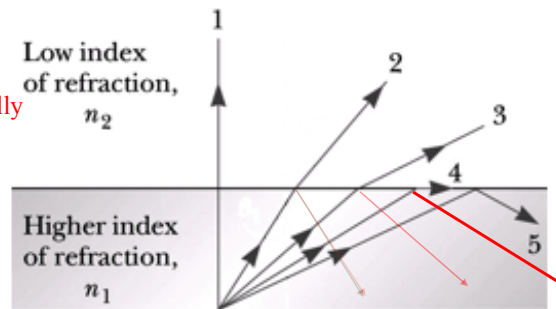
Critical Angle (θ_c) angle of incidence for which the angle of refraction is 90°

Formula:

$$n_i \sin\theta_i = n_r \sin\theta_r$$

θ_c 90

$$\theta_c = \sin^{-1}\left(\frac{n_r}{n_i}\right)$$

1. What is the critical angle as light exits from water into air?

= ?

2. What is the critical angle as light exits from water into crown glass?