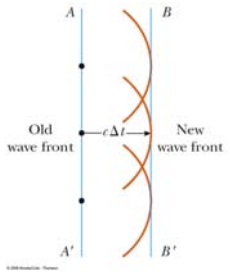
## 3.3 Reflection and Refraction II

- Huygen's Principle
- Total internal refraction
- Dispersion

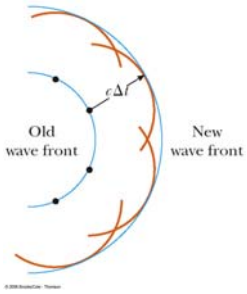
## Huygen's Principle

- All points in a given wave front are taken as point sources for the production of spherical secondary wavelets which propagate in space. After some time the new wave front is the tangent to the wavelets.

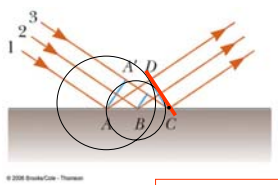
## Huygen's Picture of a Plane wave

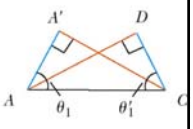



## Huygen's Picture of a Spherical wave



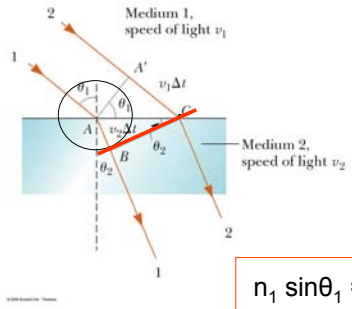

## Huygen's Explanation of Reflection




$\theta_1 = \theta'_1$

## Huygen's explanation for Refraction




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

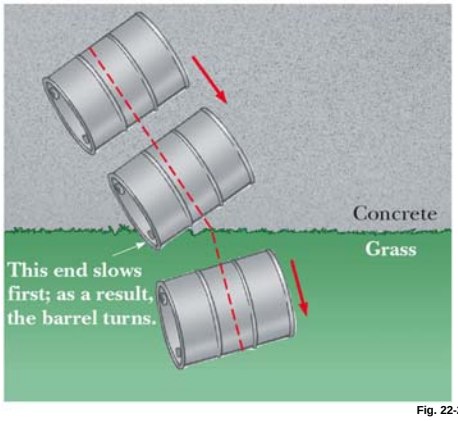
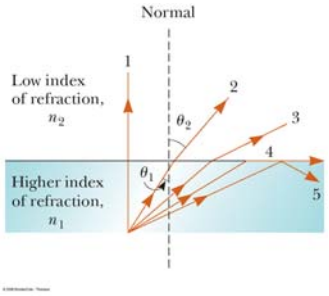



Fig. 22-24b, p.741

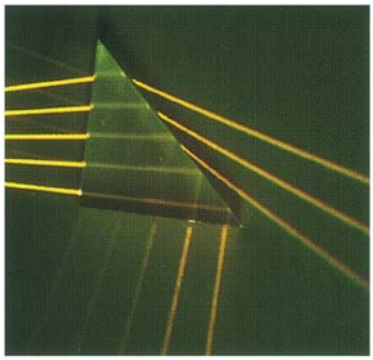
## Total Internal Reflection




When the angle of refraction equals or exceeds 90°

All the light is internally reflected

## Total Internal Reflection



## Optical Fiber -Light Pipe

An optical fiber (light pipe) confines the light inside the material by total internal reflection. If the refractive index of the fiber is 1.52 what is the smallest angle of incidence possible when the light pipe is in air.

## Fiber Optics

## Dispersion

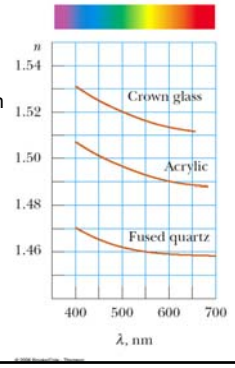
- Dispersion is the separation of light with different colors due to the wavelength dependence of the index of refraction of a prism.

## Wavelength dependence of n

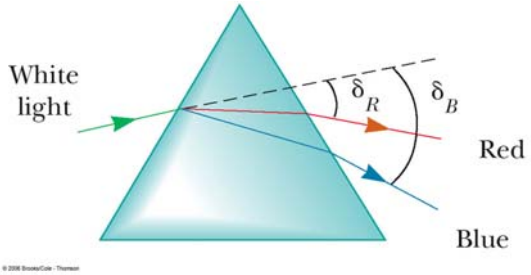
For most materials n increases with decreasing wavelength

Highest in the blue region

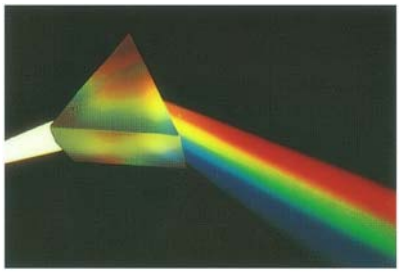
Lowest in the red region




## Different colors are refracted by different angles in a prism

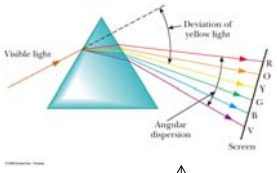



## Dispersion of light by a prism



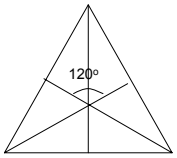
## Example

White light enters the 60° prism with an angle of incidence of 50°. If the refractive index is for red light is 1.62 and for violet light is 1.66 find the difference between the angles of refraction




A useful tip

The surface normals intersect with an angle of 120°

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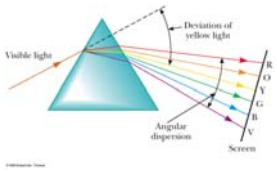
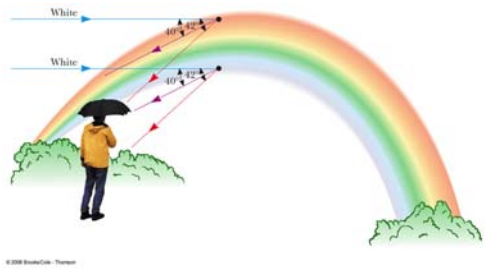



A rainbow is seen on a rainy day when the sun is to your back, low in the horizon (less than 42° above the horizon)
A second rainbow is often seen with the order of colors reversed.

The shape of the rainbow is due to parallel beam of sunlight light reflected and refracted from raindrops at a special angle (rainbow angle of 40º - 42º)
The colors of the rainbow are due to dispersion of the light.




## Dispersion of light by a rain drop

Three interfaces
A) Refraction
B) Reflection
C) Refraction

Violet light is refracted more but gives a smaller rainbow angle