Refraction, Snell's Law, Dispersion, Polarization & Scattering

Refraction

- The bending of light as it passes from one medium to another

The index of refraction is given by the equation:

$$n = \frac{c}{v}$$

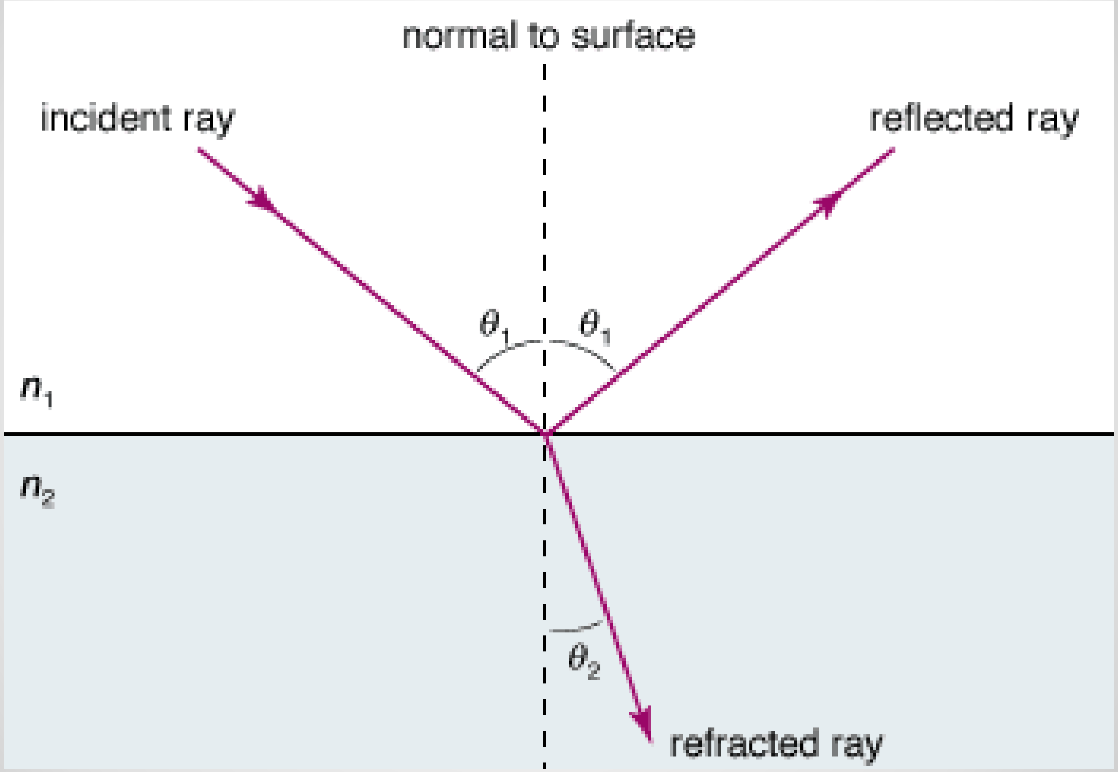
Where n is the index of refraction,

c is the speed of light in a vacuum

v is the speed of light in the medium

The Index of Refraction

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



Snell's Law

The relationship between n and λ

$n = \frac{c}{v}$ but $c = f\lambda_1$

$v = f\lambda_2$

$\therefore n = \frac{f\lambda_1}{f\lambda_2}$ f is constant

$n = \frac{\lambda_1}{\lambda_2} \Rightarrow$ For a medium, not a vacuum

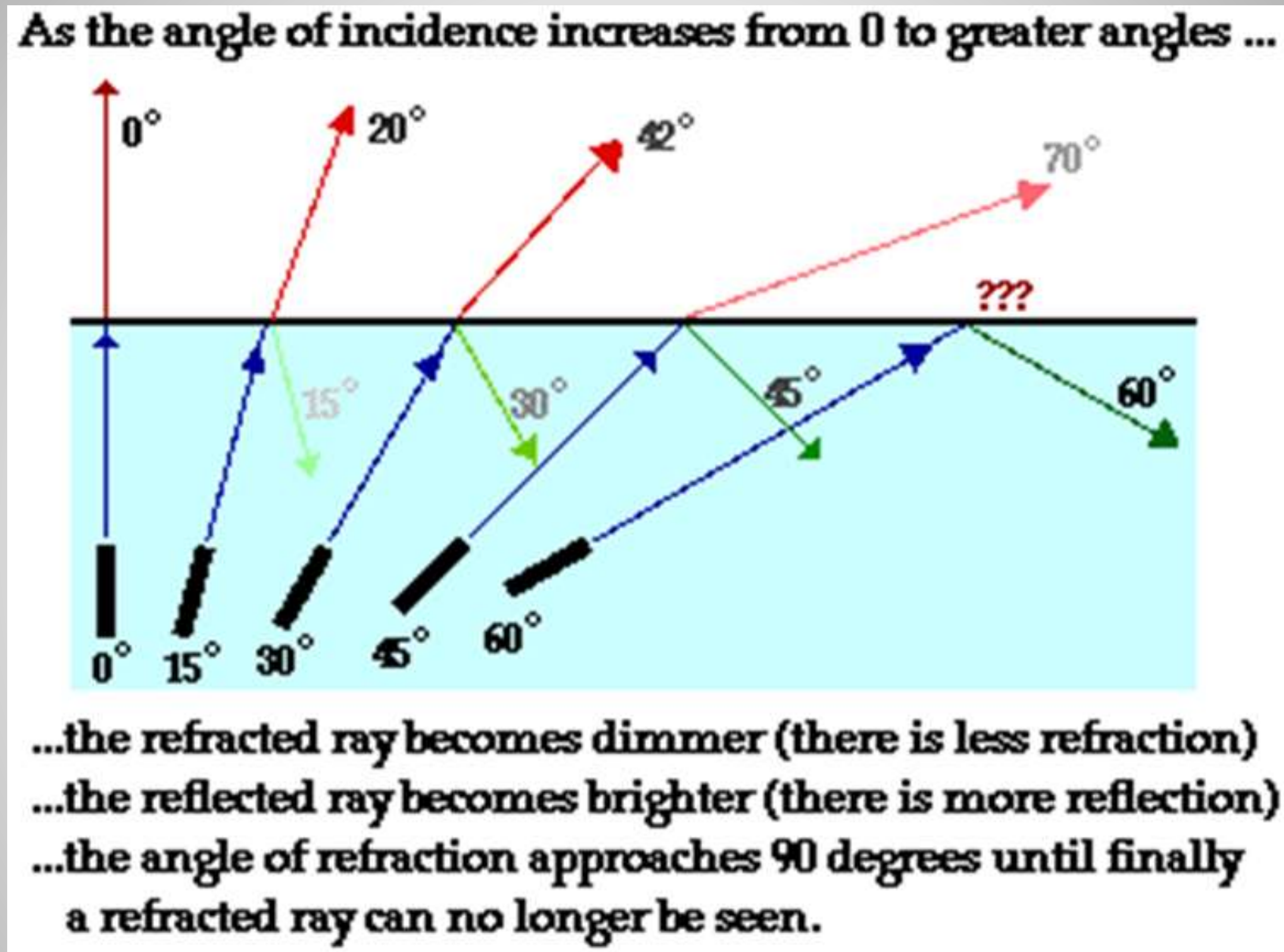
$\frac{n_2}{n_1} = \frac{\lambda_1}{\lambda_2}$

Snell's Law

- When light is refracted so much that the ray does not leave the medium, but is reflected off the boundary

- The angle at which this occurs is called the critical angle

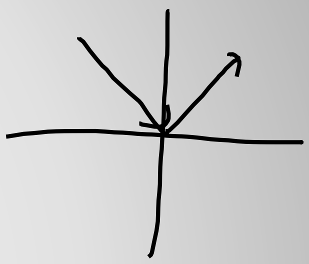
Total Internal Reflection



Total Internal Reflection

Total Internal Reflection

Example 1: Calculate the critical angle for light passing through water (n = 1.33) into air (n = 1.0003).



$n_w = 1.33$

$n_a = 1.0003$

*for critical angle $\theta_2 = 90.0°$

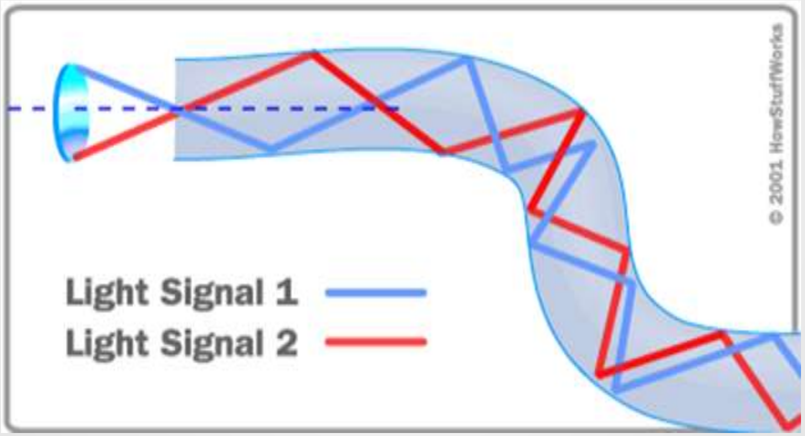
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

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

$$\theta_1 = \sin^{-1}\left(\frac{1.0003 \sin 90.0°}{1.33}\right)$$

$$\theta_1 = 48.8°$$

- Fibre optics are an application of total internal reflection



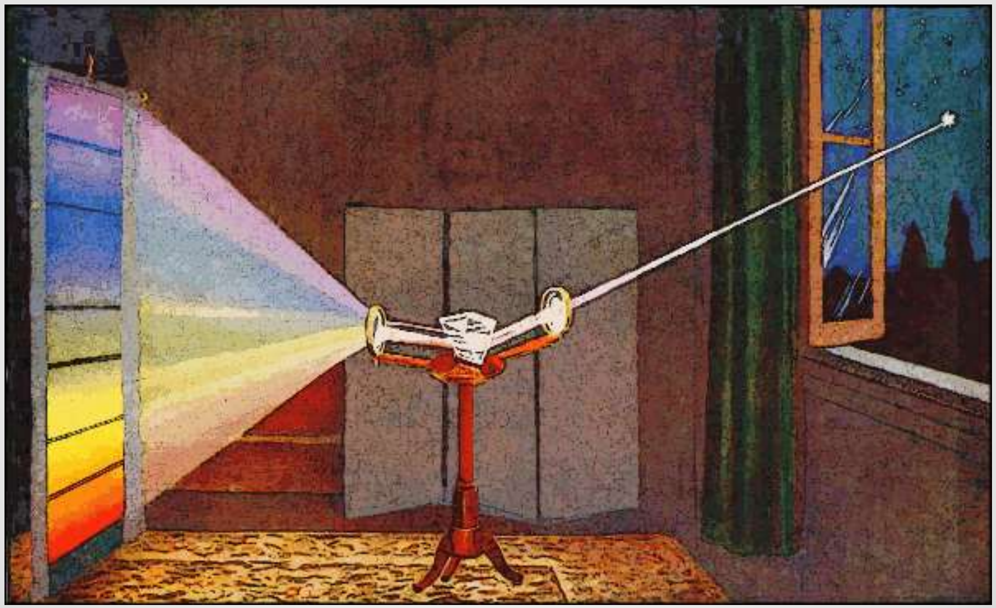
Total Internal Reflection

Dispersion

- Separating light based on wavelengths
- Indices of refraction are wavelength dependent
  - n for a type of glass ranges from 1.698 for violet light to 1.662 for red light

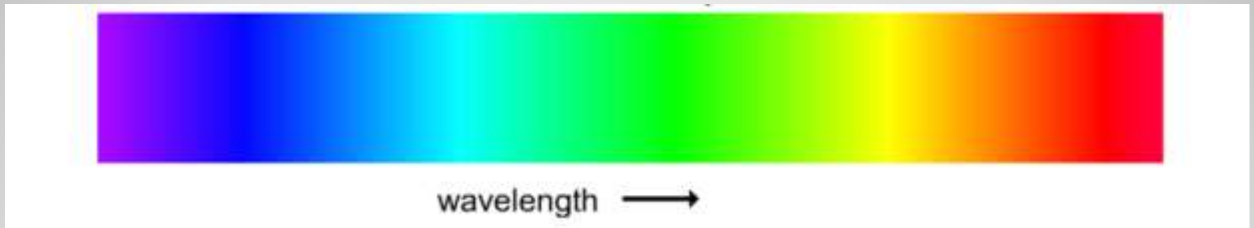
The Spectroscope

- Collects the light from a source and puts it on a spectrum

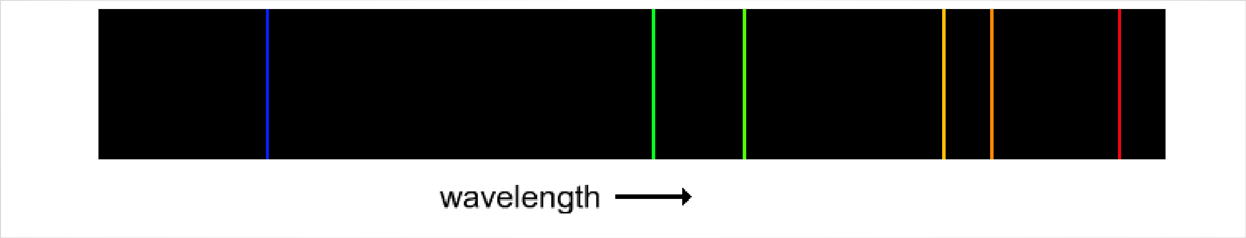


The Spectroscope

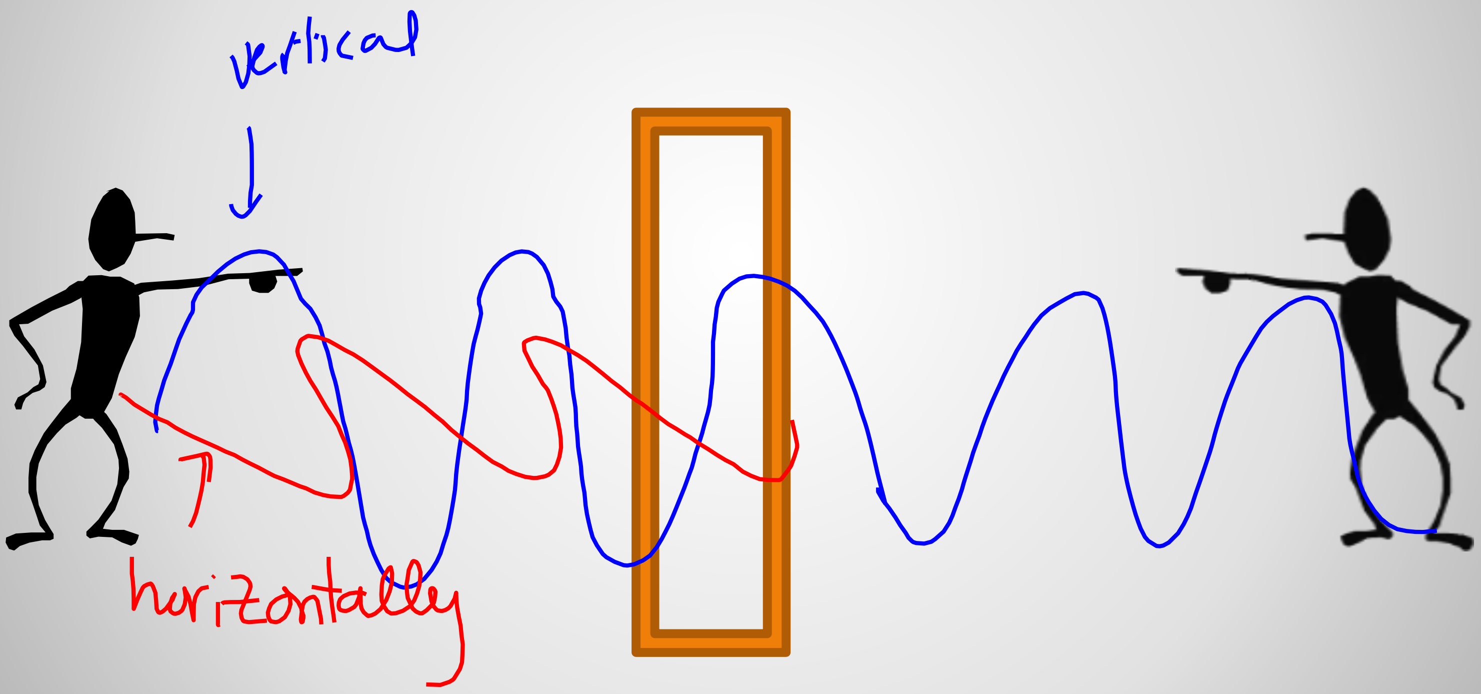
- Continuous Spectrum



- Emission / Line Spectrum

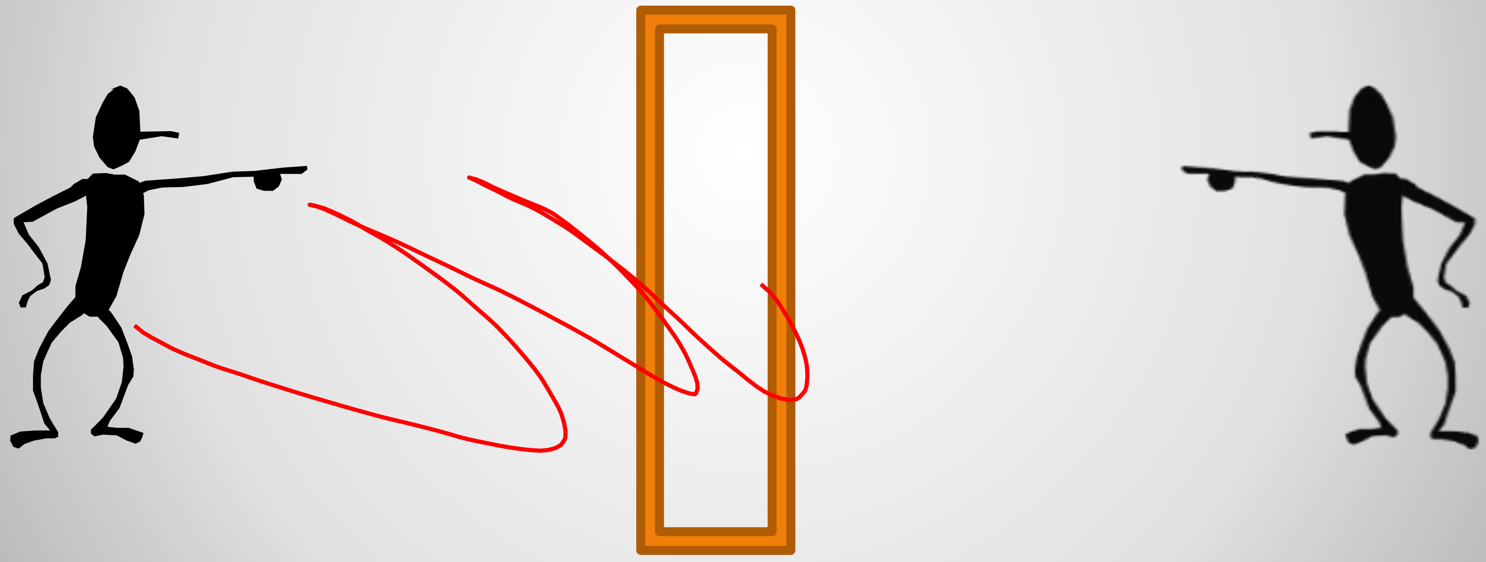


- Vertically polarized waves pass through a vertical slit



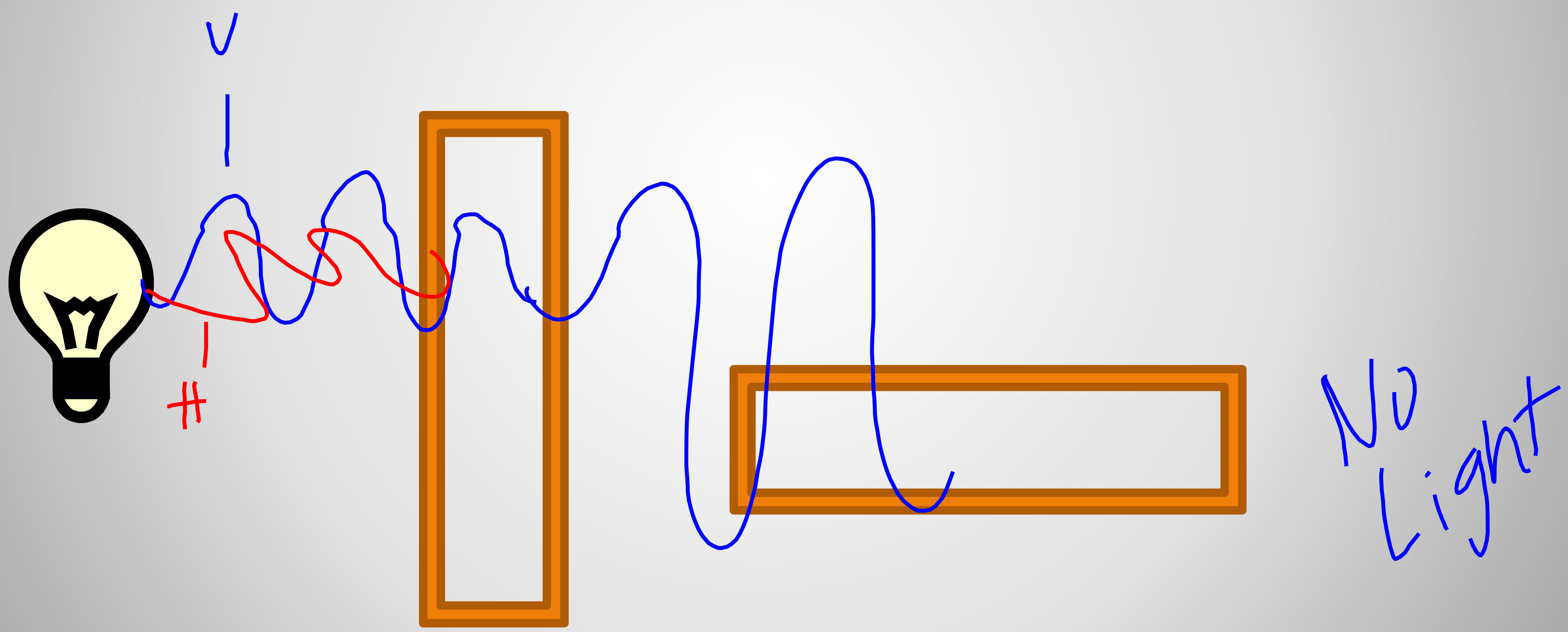
Polarization

- Horizontally polarized waves do not pass through a vertical slit



Polarization

- If light were a wave it should be able to be polarized

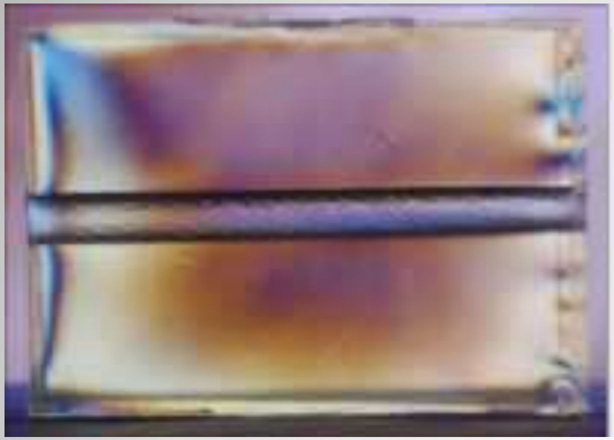


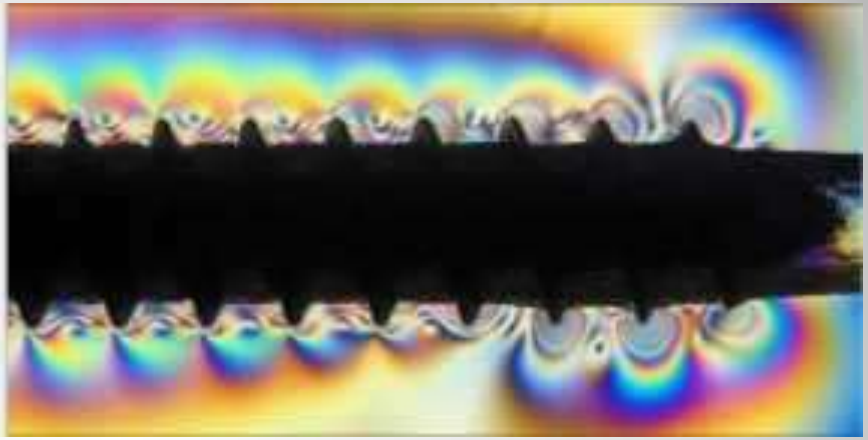
Polarization

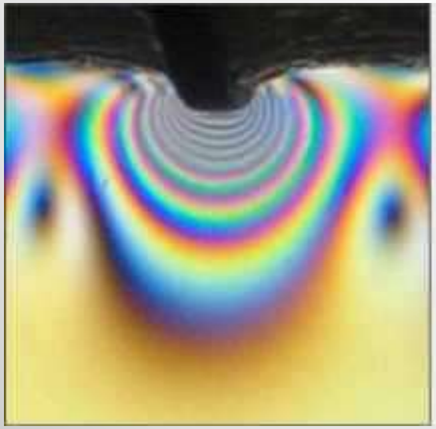
- If the linearly polarized light then passes through a filter that polarizes in the horizontal plane, nearly no light will pass through the second filter

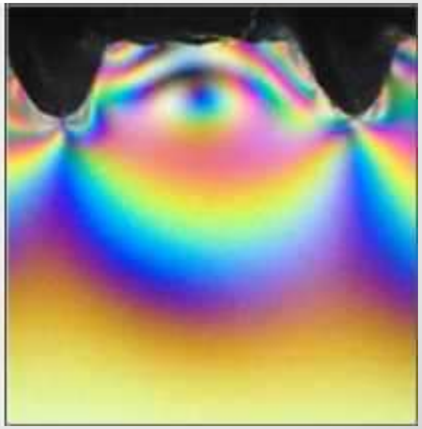
Polarization

- Photoelastic analysis





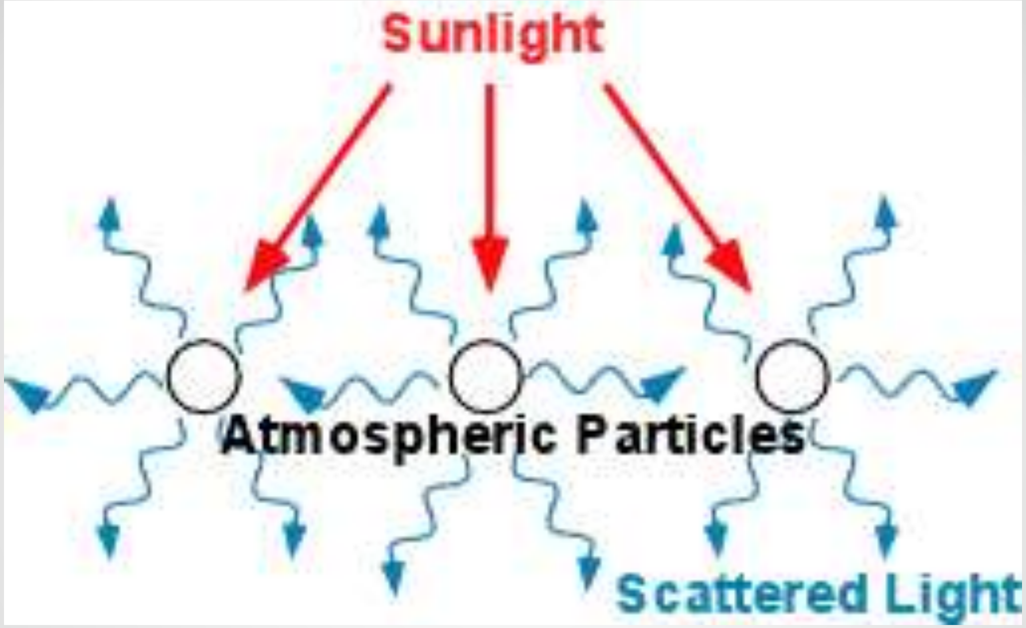




Polarization Applications

Scattering

- As light passes through the atmosphere, the waves are scattered by the particles they encounter
- Air molecules absorb the waves then re-emit their own waves
- This causes the colours in the sky



Scattering

Homework:
p. 449 # 1 – 6; p. 458 # 1, 7, 9, 10