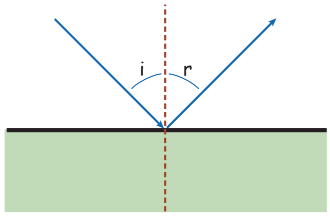
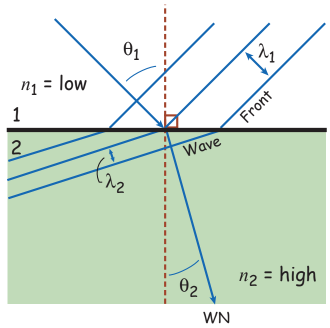
LECTURE TWO: Behaviour of Light

IN THIS LECTURE
- Reflection and refraction
- Index of refraction
- Snell's Law
- Critical Angle
- Dispersion and refractive index
- Interference phenomena
- Retardation

Reflection and Refraction
Light reaching the boundary between two transparent materials may either be reflected or refracted. For reflected light the angle of incidence (i) and the angle of reflection (r) are identical



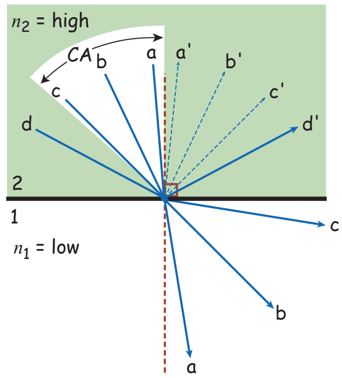
For refraction, a bent path is taken by the light on entering a new transparent material when the angle of incidence is not 90° or normal to the boundary.



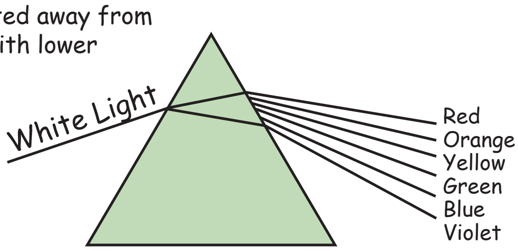
The Index of Refraction
A measure of how effective a material is in bending light is called the Index of Refraction (n), which is a function of velocity and is defined as $n = V_v/V_m$ where V_v is the velocity in a vacuum and V_m is the velocity in a material
Index of Refraction in Vacuum = 1 and for all other materials n > 1.0.
The velocity of light in most minerals is in the range 2 – 1.4 x 10^{17}nm/sec. Therefore most minerals have n values in the range 1.4 to 2.0.
A high refractive index indicates a low velocity for light travelling through that particular medium.

Snell's Law
Snell's law can be used to calculate how much light is bent on travelling from medium one to medium two and is given by $\sin \phi_1/\sin \phi_2 = n_2/n_1$.
If the interface between the two materials represents the boundary between air (n ~ 1) and water (n = 1.33) and if angle of incidence = 45°, using Snell's Law the angle of refraction = 32°.
The equation holds whether light travels from air to water, or water to air.
In general, the light is refracted towards the normal to the boundary on entering the material with a higher refractive index and is refracted away from the normal on entering the material with lower refractive index.

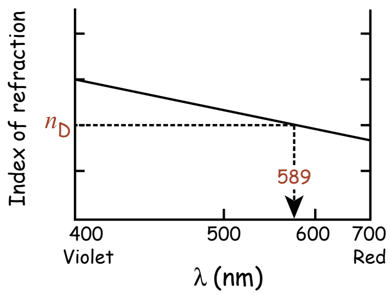
The Critical Angle
Light following wave normals a, b and c within the white arc can be refracted from the high-index to the low index materials because their angle of incidence is less than the critical angle (CA). Wave normals such as d, which have an angle of incidence greater than the critical angle are totally reflected to d' at the boundary.



Dispersion
White light is dispersed into its spectral colors when passed through a prism because the index of refraction for violet light is larger than for red light.
Therefore the index of refraction is higher for short wavelengths and lower for long wavelengths of light



Dispersion and Refractive Index
For the normal dispersion of the refractive indices, the index of refraction decreases with increasing wavelength. To describe the dispersion of a particular material it is necessary to report the index of refraction at several wavelengths. By convention indices of refraction n_F, n_D and n_C are reported for light whose wavelengths are 486, 589 and 656nm respectively. When a single index of refraction is reported it is normally n_D because 589 light is in the middle of the visible spectrum and is easily reproduced by a sodium lamp in a laboratory.



Interference Phenomena
For isotropic minerals all light is absorbed by the upper polariser and the mineral appears dark

For anisotropic minerals, light entering the mineral is split into two rays that vibrate at right angles to each other and have different indices of refraction (ie different velocities)

Because the two different rays have different velocities they travel at different speeds through the mineral. The light ray with the lower velocity is called the slow ray, the ray with the higher velocity is called the fast ray.

RETARDATION
Retardation (Δ) represents the distance the fast ray has travelled once leaving the mineral before the slow ray also leaves the mineral.
Retardation is measured in nanometres, 1nm = 10-7cm, or the number of wavelengths by which a wave lags behind another light wave.
Retardation remains constant once the two rays have left the mineral because their velocities in air will be the same.

Retardation can result in light rays constructively interfering, destructively interfering, or partially interfering