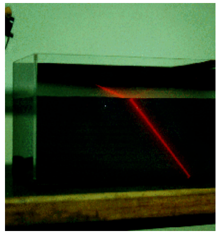
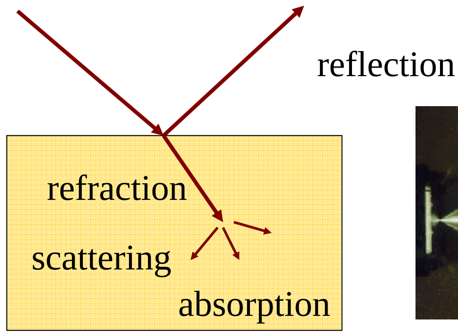
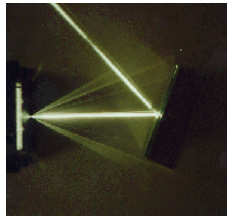
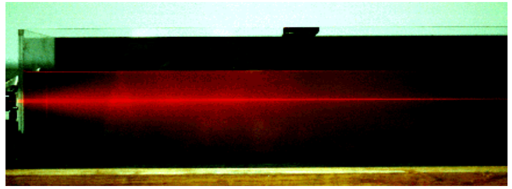
Interaction of light with matter
1.

Interaction of light with matter



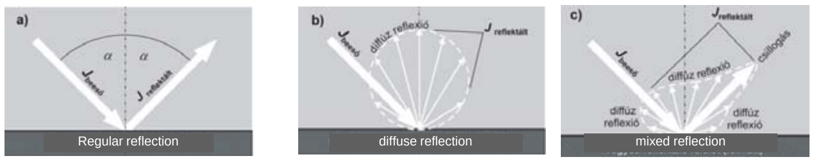




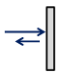


Reflection

Diffuse reflection

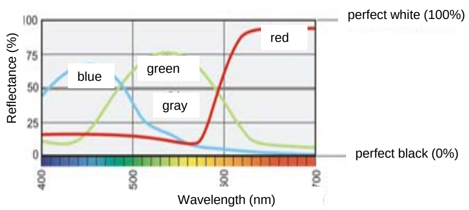


spectral reflectance $\rho(\lambda) = \frac{J_{reflected}}{J_{incident}}$

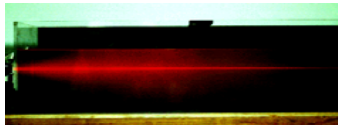


$$\rho = \left(\frac{n_2 - n_1}{n_2 + n_1}\right)^2$$

Spectrum of reflectance



Light scattering



Scattering coefficient $\sigma(\lambda) = \frac{J_{scattered}}{J_{incident}}$

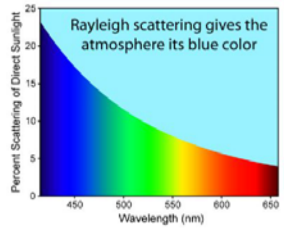
Elastic scattering: λ, f, ε are constant

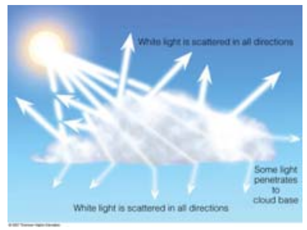
Rayleigh-scattering $d << \lambda$

$$\sigma(\lambda) \sim \frac{d^6}{\lambda^4}$$

Mie-scattering $d \geq \lambda$

No strong λ dependency





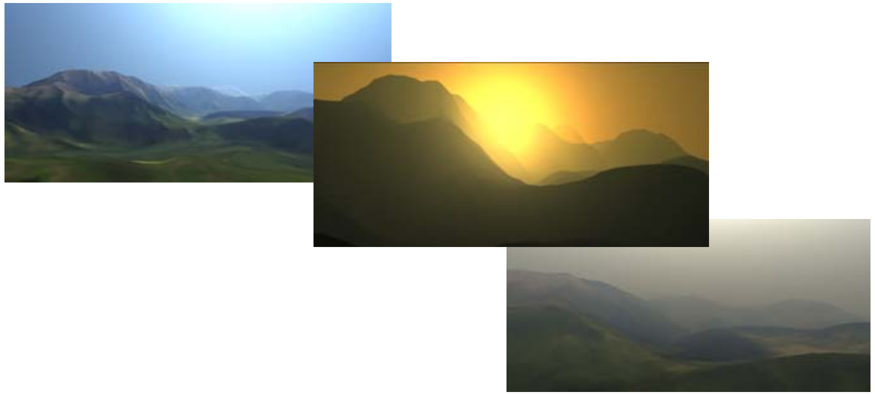
Light scattering

Rayleigh-scattering

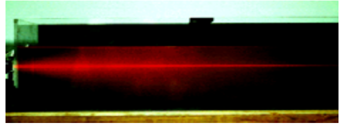
$d << \lambda$

Mie-scattering

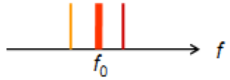
$d \geq \lambda$



Light scattering



Non-Elastic scattering: λ, f, ε are not constant



Energy transition between light and material

Raman-scattering

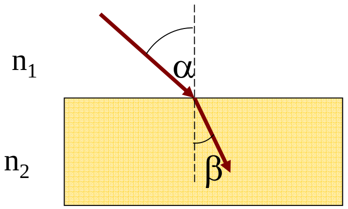
Sir Chandrasekhara Venkata Raman

Nobel Prize in physics, 1930

"for his work on the scattering of light and for the discovery of the effect named after him"

Refraction of light

Fermat's Principle: Light follows the path of least time



$n_1 < n_2$

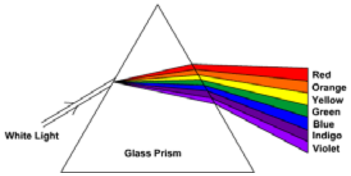
$\alpha > \beta$

Snell's Law

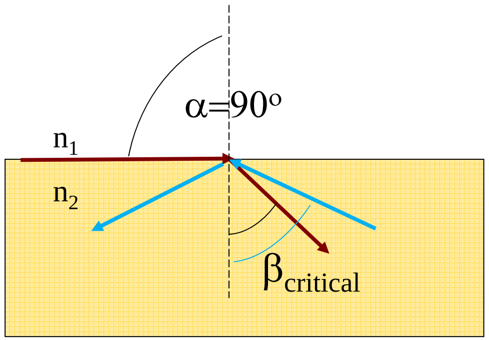
$$\frac{\sin\alpha}{\sin\beta} = \frac{c_1}{c_2} = \frac{n_2}{n_1} = n_{21}$$

The index of refraction

Dispersion of light



Critical angle – total internal reflection

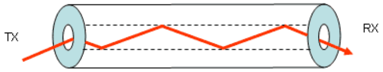


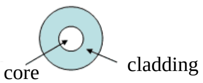
$\beta > \beta_{critical}$

Medical application

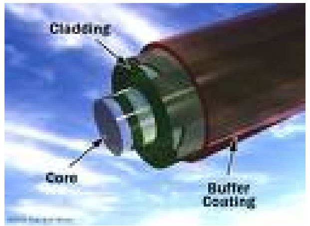
Determination of concentration – refractometry

Optical fibers

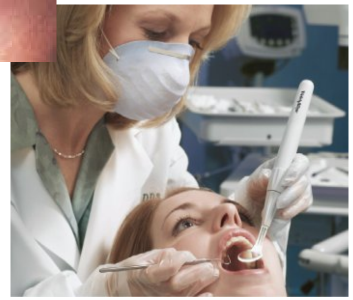




Pl. n_{core}=1,458
$n_{clading}$=1,440



Application in dentistry

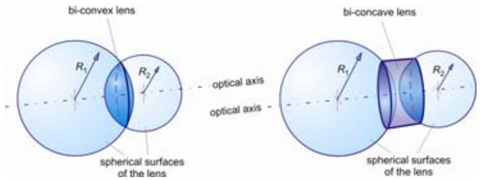


Other medical applications

Bronchoscopy

Colonoscopy

Image formation by thin lenses – Geometrical optics



Optical lenses and their interpretation by spherical surfaces

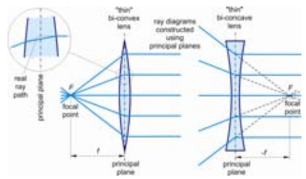
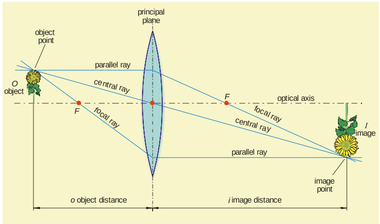
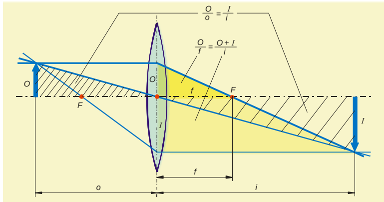


Image formation (thin lens approximation)

Image construction by principal rays





lensmaker's formula.

$$D = \frac{1}{f} = \frac{1}{o} + \frac{1}{i} = (n-1)\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

the radii of curvature

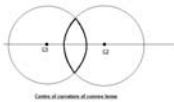
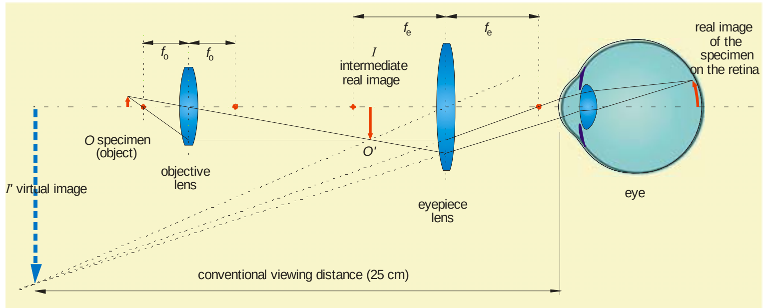


Image formation – compound microscope

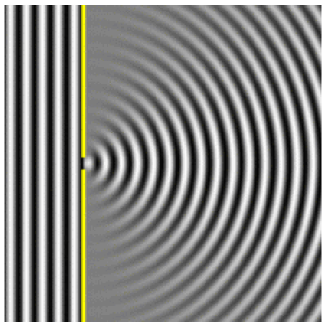


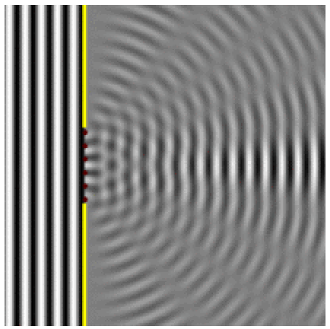
The image is magnified
reversed
virtual

Limited resolution of microscopy

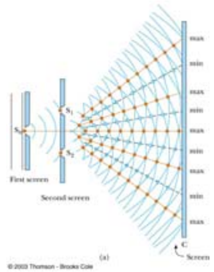
Wave nature of light

Huygens-principle

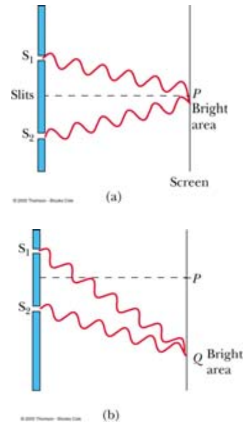




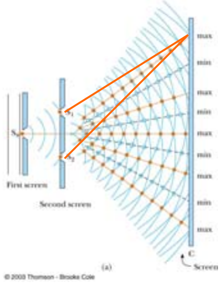
Young experiment

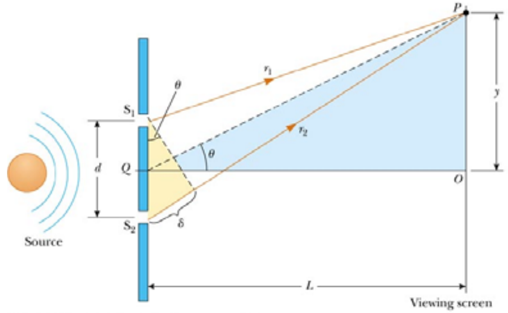


Where are the bright areas?



Young experiment

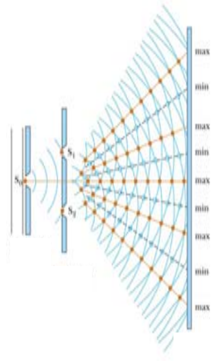


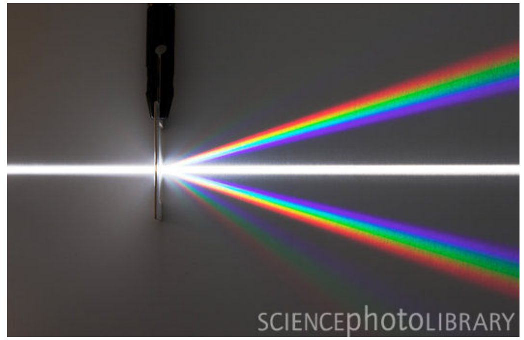


$$\delta = d \cdot \sin\Theta = k \cdot \lambda$$

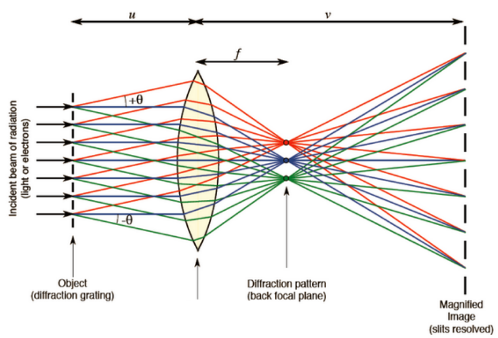
$$d = \frac{\lambda}{n \sin\Theta}$$

Dispersion of light by diffraction grating





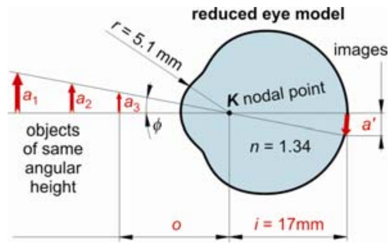
Diffraction pattern in the microscope



$$d = 0{,}61 \frac{\lambda}{n \sin\Theta}$$

Optics of the eye

Image formation of the reduced eye



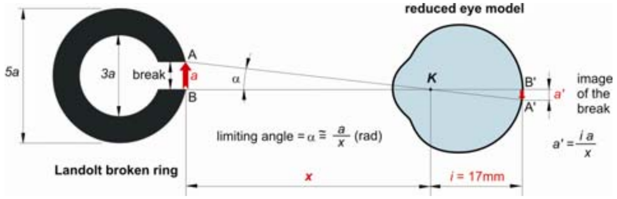
Power of the eye

Accomodation power:

$$\Delta D = D_p - D_r = \frac{1}{o_p} - \frac{1}{o_r}$$

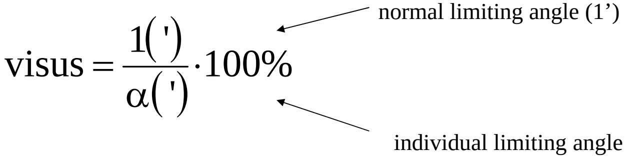
Near point

Far point



Limiting angle of view (α):

Resolution of the eye or visual acuity (visus):



Measurement of the distance of the blind spot from the yellow spot

Related chapters

Damjanovich, Fidy, Szöllősi: Medical Biophysics

II. 1.1.
- 1.1.1
- 1.1.3

II. 2. 1.
- 2.1.1
- 2.1.2
- 2.1.3
- 2.1.4
- 2.1.5
- 2.1.8

VI.3
- 3.1.1
- 3.1.2