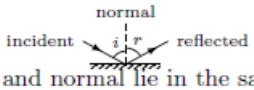
3 Optics

3.1: Reflection of Light

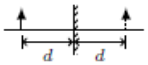
Laws of reflection:



(i)

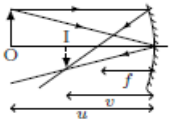
Incident ray, reflected ray, and normal lie in the same plane (ii) $\angle i = \angle r$

Plane mirror:



(i) the image and the object are equidistant from mirror (ii) virtual image of real object

Spherical Mirror:

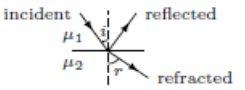


1. Focal length $f = R/2$
2. Mirror equation: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
3. Magnification: $m = -\frac{v}{u}$

3.2: Refraction of Light

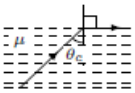
Refractive index: $\mu = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}} = \frac{c}{v}$

Snell's Law: $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$

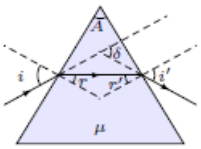


Apparent depth: $\mu = \frac{\text{real depth}}{\text{apparent depth}} = \frac{d}{d'}$

Critical angle: $\theta_c = \sin^{-1}\frac{1}{\mu}$



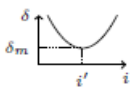
Deviation by a prism:



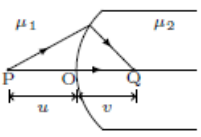
$\delta = i + i' - A$, general result

$\mu = \frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$, $i = i'$ for minimum deviation

$\delta_m = (\mu - 1)A$, for small A



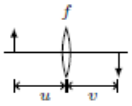
Refraction at spherical surface:



$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$, $m = \frac{\mu_1 v}{\mu_2 u}$

Lens maker's formula: $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

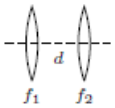
Lens formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, $m = \frac{v}{u}$



Power of the lens: $P = \frac{1}{f}$, P in diopter if f in metre.

Two thin lenses separated by distance d:

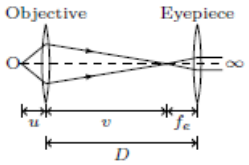
$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$



3.3: Optical Instruments

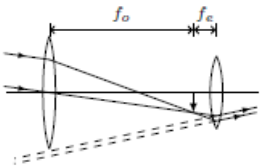
Simple microscope: $m = D/f$ in normal adjustment.

Compound microscope:



1. Magnification in normal adjustment: $m = \frac{v}{u}\frac{D}{f_e}$
2. Resolving power: $R = \frac{1}{\Delta d} = \frac{2\mu\sin\theta}{\lambda}$

Astronomical telescope:



1. In normal adjustment: $m = -\frac{f_o}{f_e}$, $L = f_o + f_e$
2. Resolving power: $R = \frac{1}{\Delta\theta} = \frac{1}{1.22\lambda}$

3.4: Dispersion

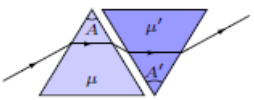
Cauchy's equation: $\mu = \mu_0 + \frac{A}{\lambda^2}$, $A > 0$

Dispersion by prism with small A and i:

1. Mean deviation: $\delta_y = (\mu_y - 1)A$
2. Angular dispersion: $\theta = (\mu_v - \mu_r)A$

Dispersive power: $\omega = \frac{\mu_v - \mu_r}{\mu_y - 1} \approx \frac{\theta}{\delta_y}$ (if A and i small)

Dispersion without deviation:



$(\mu_y - 1)A + (\mu'_y - 1)A' = 0$

Deviation without dispersion:

$(\mu_v - \mu_r)A = (\mu'_v - \mu'_r)A'$