# Geometrical Optics

### Refraction in spherical surface

$$\frac{n_1}{a} + \frac{n_2}{b} = \frac{n_2 - n_1}{R}$$

### Gauss Formula

$$\frac{1}{a} + \frac{1}{b} = \frac{1}{f}$$

### Lateral Enlargement

$$M \equiv \frac{y_b}{y_a} \qquad M = -\frac{b}{a}$$

### Focal Length Curved Mirror

$$f = -\frac{R}{2}$$

### Refractive Power (Lens)

$$B \equiv \frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

### Lens

Lens with refractive index $n_1$ in medium with refractive index $n_2$:

$$B \equiv \frac{1}{f} = \left[\frac{n_1}{n_2} - 1\right] \cdot \left[\frac{R_2 - R_1}{R_1 \cdot R_2}\right]$$

### Aparture Number

$$b_t \equiv \frac{f}{D}$$

### Depth of Field

$$s \approx \frac{a^2}{1000 f} b_t$$

### Angular Magnification of Magnifier

$$G = \frac{d_0}{f} \text{ where, } \quad d_0 = 25\,\text{cm}$$

### Angular Magnification of Microscope

$$G = |M_{ob}| \cdot G_{ok} = \frac{L}{f_{ob}} \frac{d_0}{f_{ok}}$$

where the tube length $L = 16\,\text{cm}$

### Angle magnification of the Kepler and Galileo binoculars

$$G = \left|\frac{f_{ob}}{f_{ok}}\right|$$

### Refraction in a spherical surface

Positive if: C is to the right of O
- Positive if: A is to the left of O
- Positive if: B is to the right of O
- Positive if: $F_A$ is to the left of O
- Positive if: $F_B$ is on the right of O

Image with thin lens in air
- Positive if: the lens is convex (gathers light)
- Positive if: the object is to the left of the lens
- Positive if: the image is to the right of the lens
- Positive if: the object is above the optical axis
- Positive if: the image is above the optical axis
- Positive if: the image is upside up

Image with a curved mirror
- Positive if: C is to the right of O (convex)
- Positive if: F is to the left of O (concave)
- Positive if: A is to the left of O
- Positive if: B to the left of O
- Positive if: the image is upside up

### Refractive Index for Some Materials

Refractive Index with $\lambda = 589\,\text{nm}$ at 20 °C:

| | |
|---|---|
| Water | $1,333$ |
| Diethyl Ether | $1,353$ |
| Ethanol | $1,361$ |
| Glycerin | $1,455$ |
| Benzene | $1,501$ |
| Carbon Sulfur | $1,628$ |
| Is (0 °C) | $1,31$ |
| NaCl | $1,544$ |
| Polystyrene | $1,59$ |
| Crown Glass (FK5) | $1,487$ |
| Crown Glass (BK7) | $1,517$ |
| Canada balsam | $1,542$ |
| Flint Glass (F2) | $1,620$ |
| Flint Glass (SF10) | $1,728$ |
| Flint Glass (SFS1) | $1,922$ |
| Quarts | $1,458$ |
| Plexiglass | $1,49 - 1,52$ |
| Diamond | $2,417$ |