Optical components

Hongjie Lu

2018-02-04

1 Refraction

1.1 Planar interface

- Snells law
- external reflection ($n_1 < n_2$): ray refracted away from the interface
- internal reflection ($n_1 > n_2$): ray refracted towards the interface
- total internal reflection (TIR) for: $\theta_2 = \frac{\pi}{2} \Rightarrow sin\theta_1 = sin\theta_{TIR} = \frac{n_2}{n_1}$ Normally, the definitions of "internal" and "external" are with respect to the medium the light is emerged from. Total internal reflection is more common in application, however, total external reflection normally refers to X-rays whose indices of refraction for all materials are all slightly below 1. This entails that total reflection of X-rays only can occur when they travel through vacuum and impinge on a surface (at a small glancing angle). Since this kind of total reflection takes place outside of the material it is termed total external reflection.

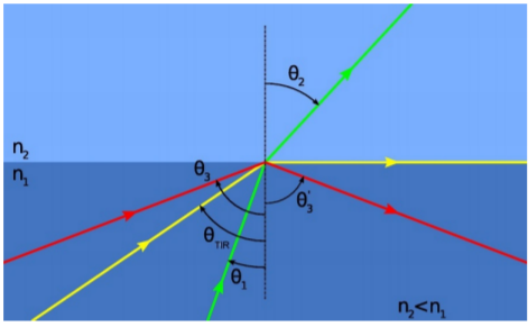

Figure 1: Planar interface

1.2 Spherical interface (paraxial)

as shown in "Geometrical optics" part

1.3 Spherical thin lens (paraxial)

as shown in "Geometrical optics" part

2 Reflection(Mirror)

2.1 Planar mirror

- Rays originating from P1 are reflected and seem to originate from P2.

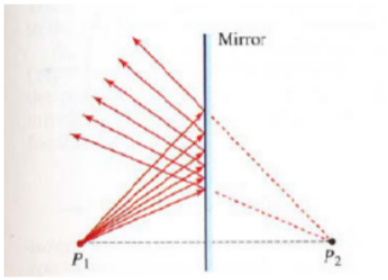

Figure 2: Planar mirror

2.2 Paraboloidal mirror

- parabolic or paraboloid or paraboloidal mirror
- Parallel rays converge in the focal point (focal length f).
- Applications: Telescope, collimator

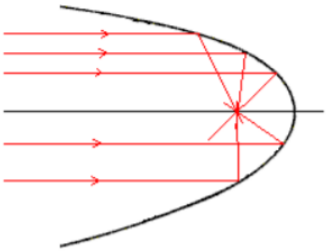

Figure 3: paraboloidal mirror

2.3 Ellipsoidal mirror

- Rays originating from focal point P_1 converge in the second focal point P_2

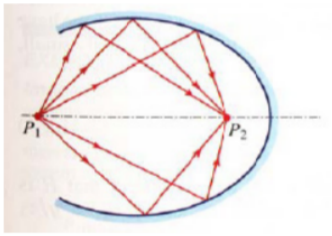

Figure 4: Ellipsoidal mirror

2.4 Cylindrical mirror

2.5 Spherical mirror

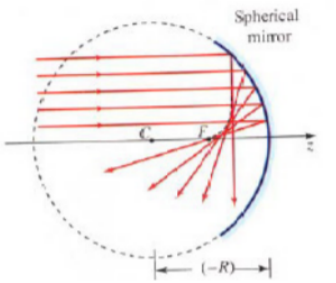

Figure 5: Spherical mirror

- Neither imaging like elliptical mirror nor focusing like parabolic mirror
- parallel rays cross the optical axis at different points
- connecting line of intersections of rays $\rightarrow$ caustic
- parallel, paraxial rays converge to the focal point $f = (-R)/2$
- convention: $R < 0$ - concave mirror; $R > 0$ - convex mirror
- for paraxial rays the spherical mirror acts as a focusing as well as an imaging optical element. paraxial rays emitted in point P_1 are reflected and converge in point P_2. $\frac{1}{z_1} + \frac{1}{z_2} \approx \frac{2}{-R}$
- paraxial imaging: imaging formula and magnification. $m = -\frac{z_2}{z_1}$

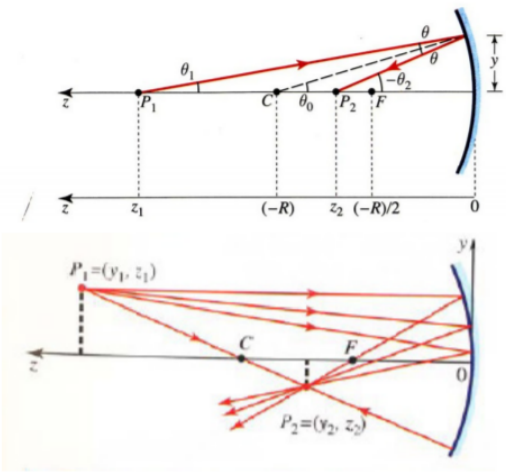

Figure 6: Spherical mirror paraxial

2.6 Toroidal mirror

Toroidal mirrors are focusing devices having two different radii whose axes are oriented perpendicularly. They are utilized in instances where a beam must be focused and folded. Rather than using both a spherical mirror and a plane mirror for this purpose, both functions may be combined in one element. Toroidal mirrors also correct for the astigmatism that result when a spherical mirror is used off axis.
Toroidal mirrors are aspherical mirrors where each curvature of orthogonal two axes (horizontal and vertical one) are different. Barrel or Tire shaped with a rotation axis are available.

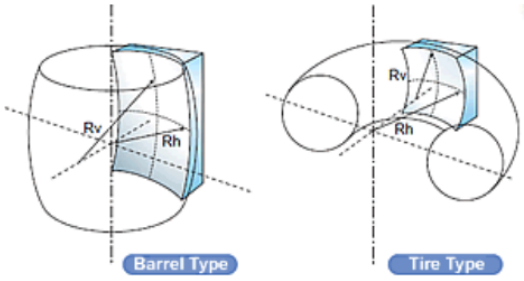

Figure 7: Toroidal mirror

3 reference

Lecture slide "Fundamentals of Modern Optics" of Jena

4 Index

The Polar coordinates form of conic sections