Aspheric Surfaces

- Simple optics uses spherical surfaces
- Spherical surface is defined by the radius of curvature only
- But to correct many aberrations need aspheric surface
- Aspheric from Greek: a means not: thus not spherical
- Must have curvature different with radius r from optic axis
- Define a “sag” from the spherical curve
- Most common formula: rotated symmetric surface with a sag
- Define curve position along the z optic axis as

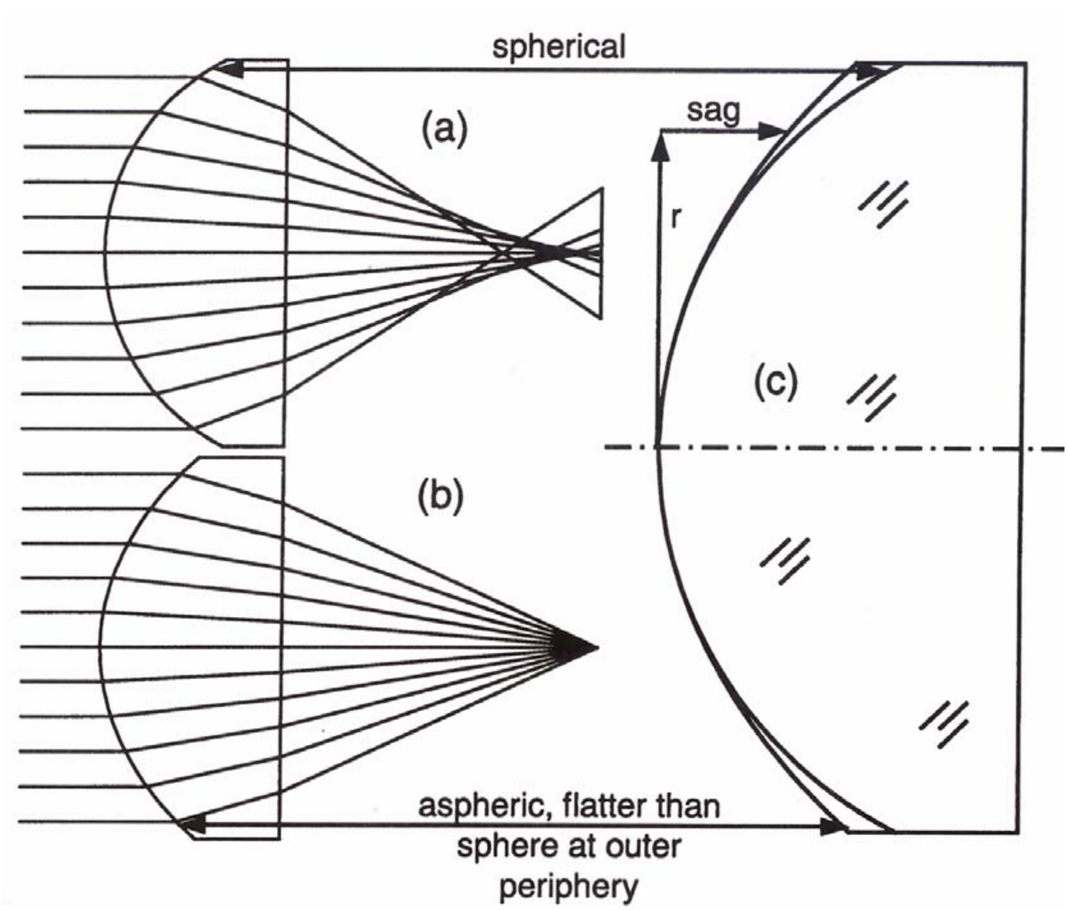
$$z = \frac{cr^2}{1 + \sqrt{1 - (1+k)c^2 r^2}} + \sum_{i=1}^{n} a_i r^{2i}$$

Where c = base curvature at vertex

k = conic constant

r = radius from optic axis

$a_i r^2$ = higher order aspheric terms

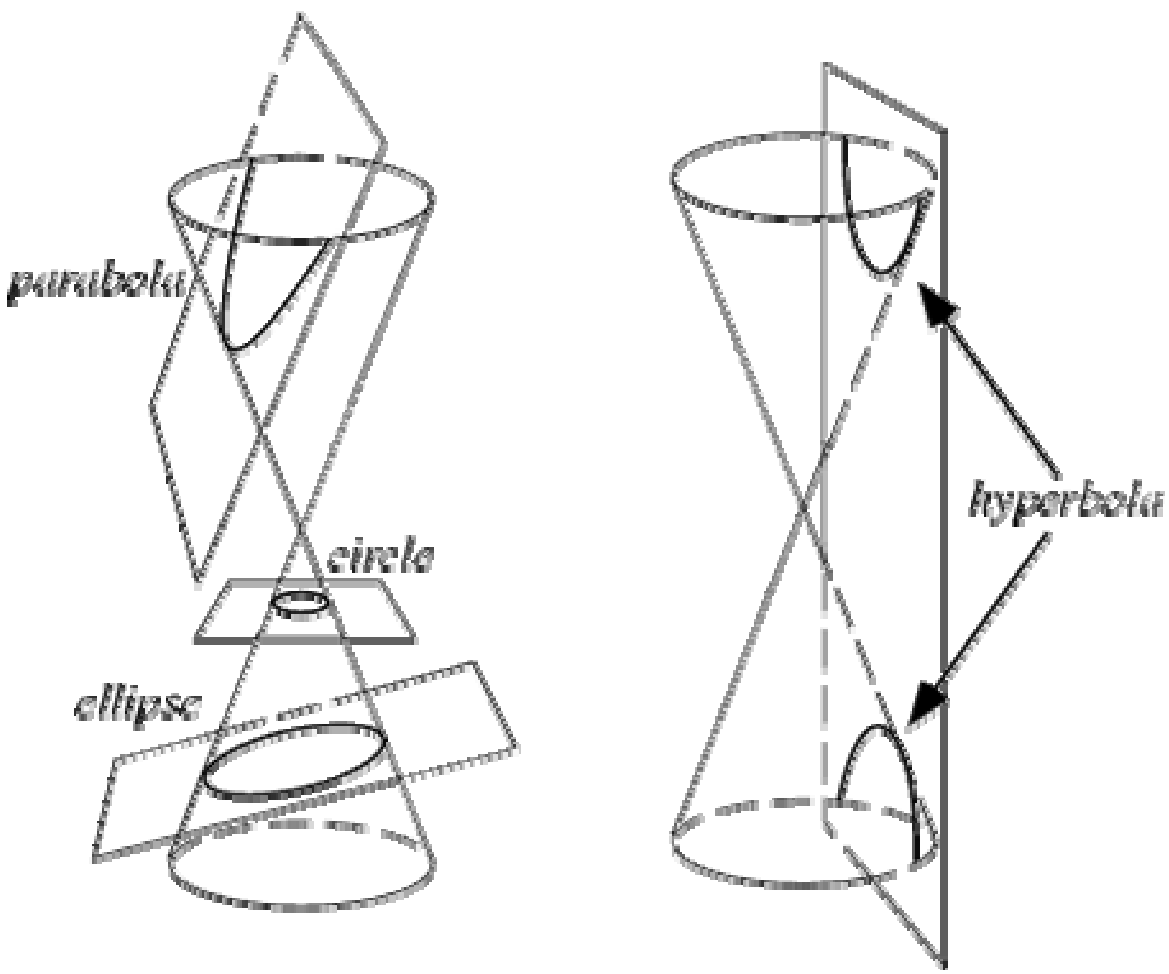


Conic Surfaces

- Conic surfaces are those made by a plane intersecting a cone
- Parabola, Hyperbola, Ellipse are common conics
- Rotate all these surfaces to get Paraboliods, Ellispoid etc
- In aspheric these drop higher order aspheric sag terms thus

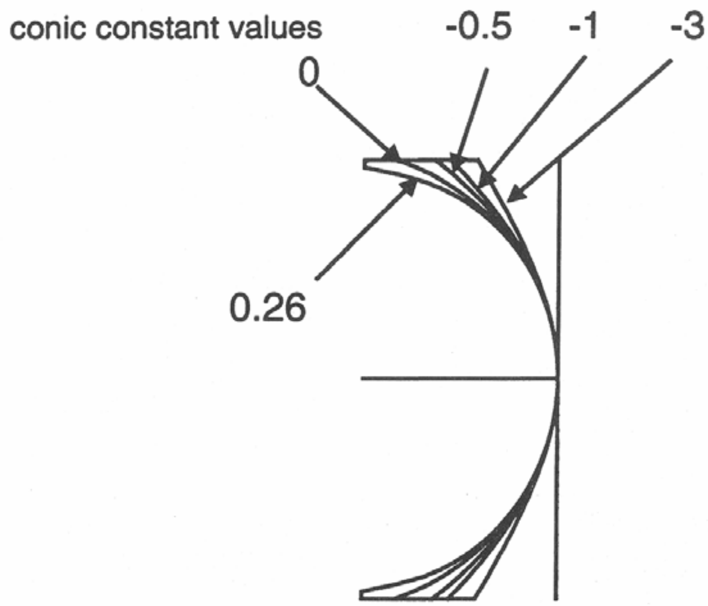
$$z = \frac{cr^2}{1 + \sqrt{1 - (1+k)c^2 r^2}}$$

Conic Constant	**Surface Type**
k = 0	spherical
k = -1	Paraboloid
k < -1	Hyperboloid
-1 < k < 0	Ellipsoid
k > 0	Oblate eliposid



Effect of Conic Constant k

- Conic surface free of spherical aberrations under certain conditions
- Each type has a set of conjugate (related) points where this true
- Spherical: no aberration if object at center of curvature
- Parabolic mirror: for object at infinity
- Ellipsoid: for pair of real image conjugates on same side of surface
- Hyperboloid: conjugates on 2 different sides of surface
- Note how surface changes with conic constant k
  when base curvature c is kept constant.



Mirror and Parabolas

- For mirrors mostly want object near infinity
- Or to project light to infinity
- Parabolic surface creates this correction
- With aspheric formula k=-1 and

$$z = cr^2$$

- Classic parabola formula is

$$r^2 = 2pz$$

- Focus of parabola is at

$$f = \frac{p}{2} = \frac{1}{4c}$$

- Related to spherical focus which is at f=r/2
- Change from sphere is small so can correct with correcting lens
- Seen in Schmit Telescope

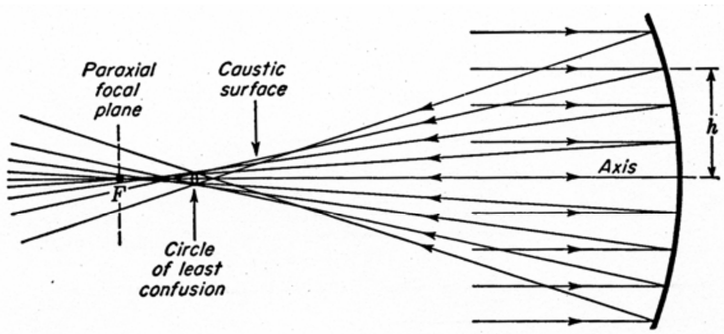
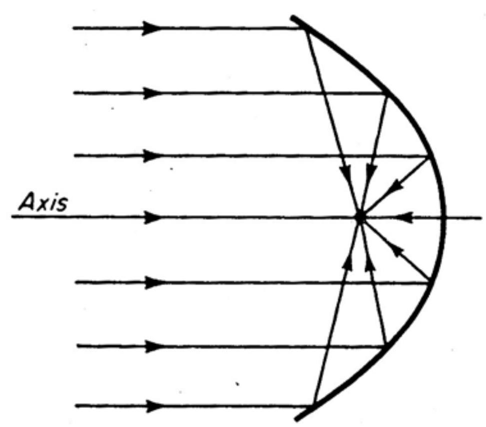
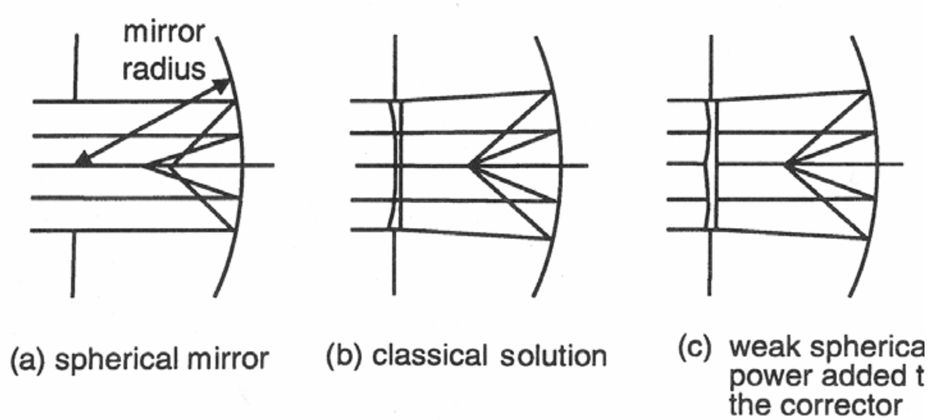


FIGURE 6K
Spherical aberration of a concave spherical mirror.



Paraboloidal mirror



Schmit Telescope
With correction plate

Correcting Astigmatism

- To correct astigmatism need higher order terms
- Astigmatism is deferent focus point further from axis
- Require changing shape to extend focus with r
- Stick as close to conics as possible in general

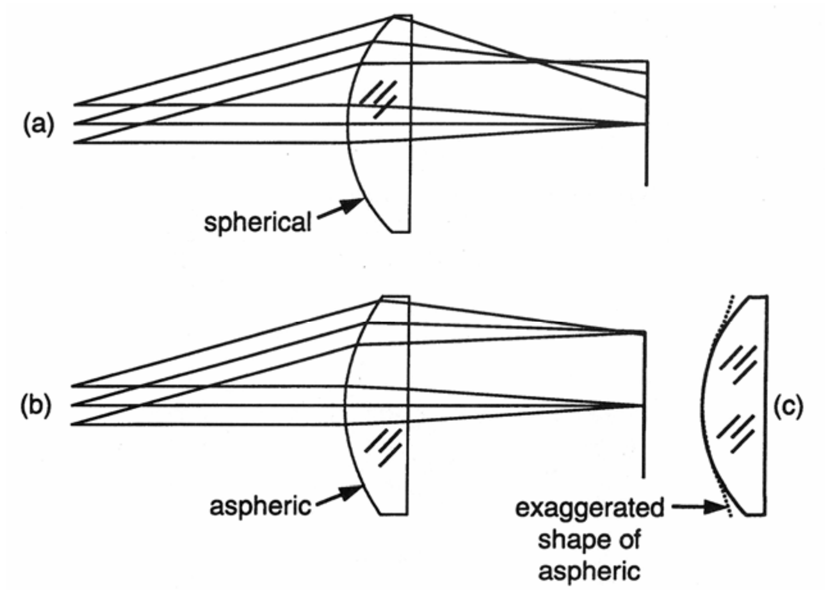
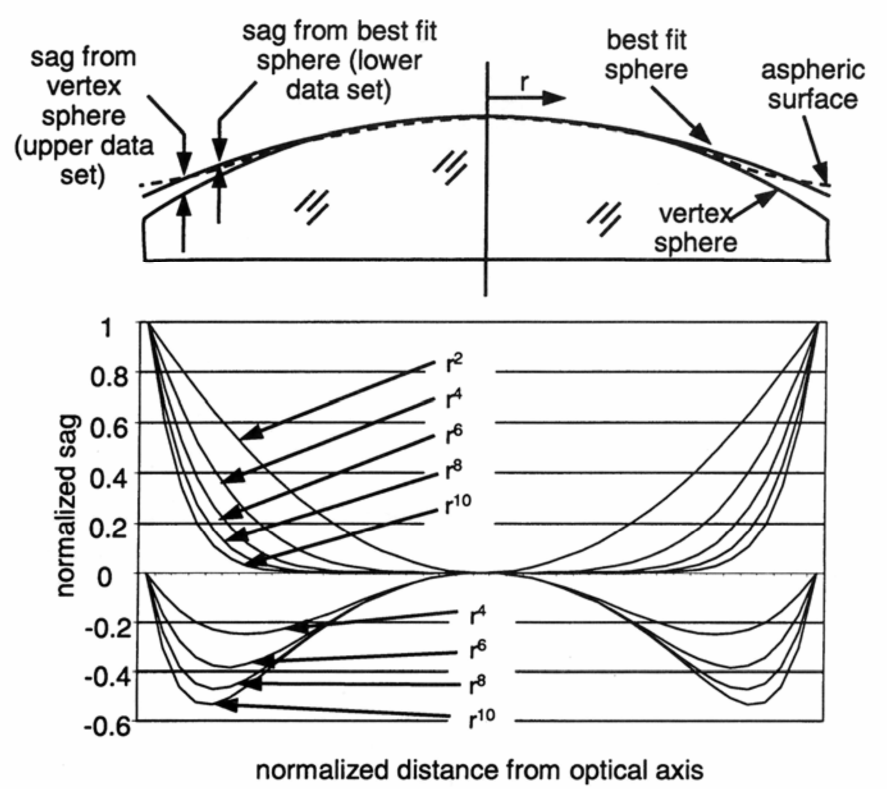


Figure 7.8
Aspheric Sags from Vertex Sphere (Top) and Best-Fit Sphere (Bottom)



Aspheric Lens and Design

- Must use CAD tools for Aspheric lens design
- Generally do not use several aspheric lenses together
- Higher order terms my combine
- Generally design an special aspheric for the system
- Hard and expensive to manufacture if more than simple conic