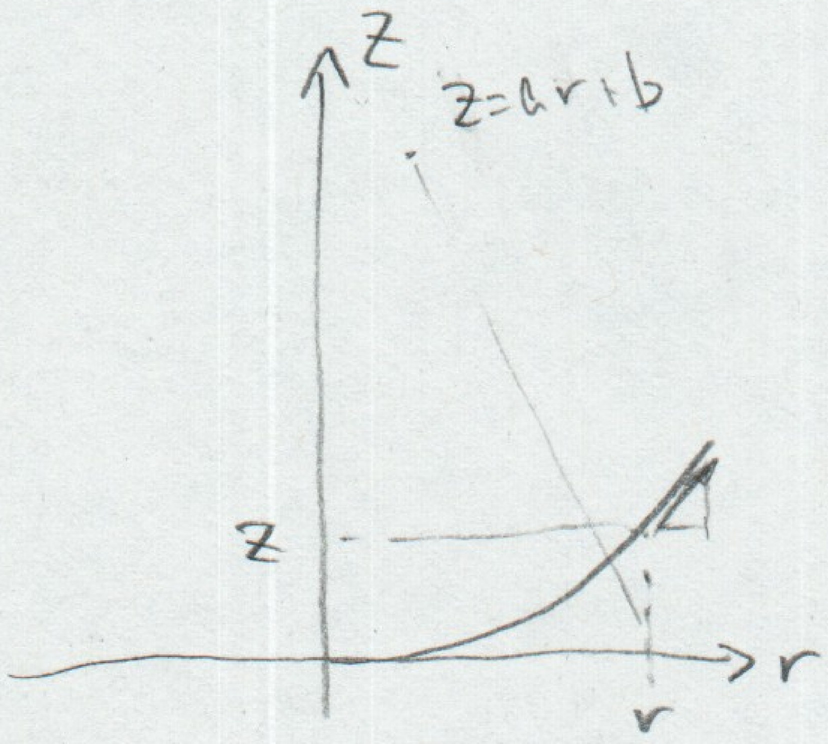
For Ray Tracing Program



aspheric surface $Z(r)$ can be described as

$$Z(r) = \frac{Cr^2}{1+\sqrt{1-(1+k)C^2r^2}} + Ar^2 + Br^4 + Cr^6 + \cdots$$

$$\frac{dZ(r)}{dr} = \frac{1}{\{1+\sqrt{1-(1+k)C^2r^2}\}^2}\left\{2Cr\cdot\{1+\sqrt{1-(1+k)Cr^2}\} + \frac{Cr^2\cdot(1+k)C^2r}{\sqrt{1-(1+k)C^2r^2}}\right\}$$

$$+ \sum_{k=0} k A_k r^{k-1}$$

normal vector :

$$\begin{cases} \left(\frac{dZ(r)}{dr}, -1\right) & \cdots\ r>0 \\ \left(-\frac{dZ(r)}{dr}, 1\right) & \cdots\ r<0 \end{cases}$$

cross point :

$$Z(x,y) = Z(\sqrt{x^2+y^2})$$

ray :

$$\begin{cases} x = x_0 + l\,dx \\ y = y_0 + l\,dy \\ z = z_0 + l\,dz \end{cases}$$

... maybe there are no analytical solution...

l shoul be derived by iteration

$\underline{l=0}$ bool upper = $(Z(x_0,y_0) > z_0)$

do { if $((Z(x_0+l\,dx) > z_0+l\,dz)$ ^ upper) l x= 2.0

(^ XOR)

else $x_0 = x_0 + 0.5 \times l\,dx$

while $(|Z(x_0+l\,dx) - z_0| < \varepsilon)$.