

Clarifications on Quiz I Review

1. Propagation distance inside matter. Matrix Method does not calculate the Optical Path Length.

In ray tracing, the most important variables are the height and the angle of the ray.

$$\begin{pmatrix} x_{out} \\ \theta_{out} \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} x_{in} \\ \theta_{in} \end{pmatrix}$$

We do not calculate the actual "optical path length" in the matrix method. All we do is compensate for the change in the angle, affected by the shape of the surface and the change in the refractive index. When light enters a square block of glass and leaves the block, the matrix is the following.

$$\begin{pmatrix} 1 & 0 \\ 0 & n \end{pmatrix} \begin{pmatrix} 1 & d \\ 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & 1/n \end{pmatrix} = \begin{pmatrix} 1 & d/n \\ 0 & 1 \end{pmatrix}, \quad \therefore \begin{pmatrix} x_{out} \\ \theta_{out} \end{pmatrix} = \begin{pmatrix} x_{in} + \frac{L}{n} \theta_{in} \\ \theta_{in} \end{pmatrix}$$

Therefore, the difference between the input and output height $\Delta x = x_{out} - x_{in}$ is smaller inside glass.

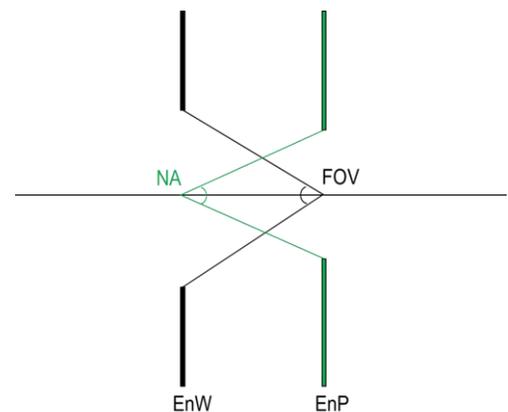
$$\begin{aligned} \Delta x_{L,air} &> \Delta x_{L,glass} \\ L\theta_{in} &> L\theta_{in} / n \end{aligned}$$

The OPL, on the other hand, is $\int n \cdot dl$: longer inside glass.

2. FOV

There are two types of Field of View, defined for the entrance and the exit of the system. Normally, when the entrance FOV can be defined, this is what you are asked to calculate, as below.

The exit FOV can be calculated by replacing EnW with ExW, and EnP with ExP. This normally does not equal the entrance FOV.

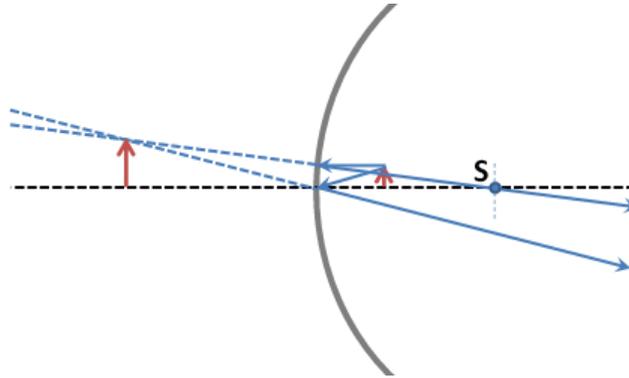


In the solution for 2012 Quiz 2 Problem 1-d), the FOV should be calculated from $2 \cdot (1.5/27)$ instead of $2 \cdot (1.5/25)$.

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3. Elliptical Mirror Cavity and the Paraxial Approximation.

The solution provided for Quiz2012_P2 is correct.



A curved surface is approximated as a parabola in the paraxial approximation

Paraxial approximation is the only way to produce an image inside an elliptical mirror cavity, although this produced image is still blurry. Ray tracing with two representative rays that go through the foci does NOT give you an image.

How paraxial approximation produces an image: In the paraxial approximation, curved surface is approximated as a parabola. A spherical or elliptical surface is also approximated as a parabola, which means that a paraxial ray will always go through the focal point: which is why you can claim the existence of an image. Again, this is not a perfect image. It will be blurred.

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