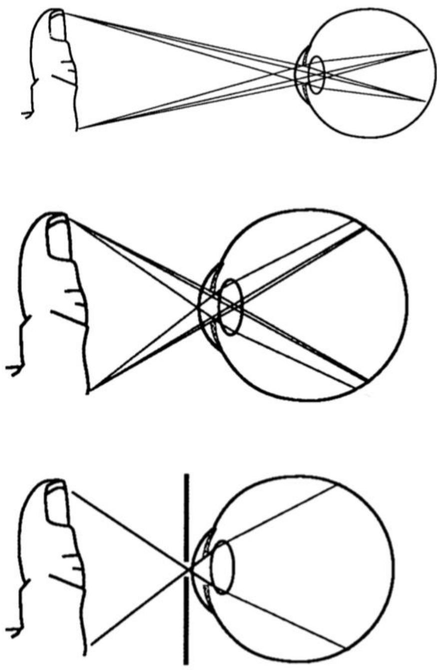
Solution- III

Optics

Problem 1:

Since the lenses are not perfect and they have an aberration, therefore if the light goes through the edge of a lens it will focus in different point and make a blurred image. The aperture helps us to remove this blurred light and therefore we can bring the object closer. However, the aperture will block some part of light and reduce the intensity of image.



Problem 2:

E = exposure

$$N = \frac{f}{D}, Ev = \ln\left(\frac{N^2}{t}\right)$$

$$\frac{t_2}{t_1} = \frac{N_2^2}{N_1^2}$$

$$N_2^2 = \left(\frac{1/120}{1/30}\right)(121)$$

$$N_2 = 5.5$$

Problem 3:

Given that focus of two positive lenses are $f_1 = f_2 = 25$mm

Object is placed at $s_{o1} = 27$ mm

According to the lens maker's formula,

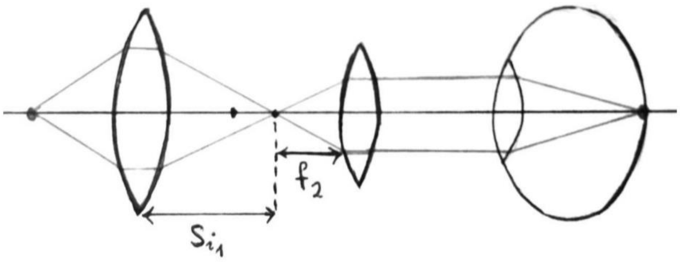
$$\frac{1}{f_1} = \frac{1}{S_{o1}} + \frac{1}{S_{i1}}$$

$$\frac{1}{S_{i1}} = \frac{1}{25} - \frac{1}{27}$$

$$S_{i1} = 337.5 \text{ mm}$$

Which means the image formed at a distance of 337.5mm

But, for a Normal eye the near point is at 254 mm



$s_{i1} + f_2 = 362.5$ mm

for ocular (it is a magnifier):

Magnifying Power MP = (it is the ratio of the size of the retinal image as seen through the instrument over the size of the retinal image as seen by the unaided eye at normal viewing distance)

MP= d_0/L [1 + D (L + l)]

if: f = s_0 (ie. Object is placed at the focus) ⇒ L = ∞

⇒ MP = d_0D, D = 1/f

Hence the lenses should keep at a distance given by;

⇒ d_0 = 254 mm

The total magnification will be;

$M_{tot} = \frac{-S_i}{S_o} \, (d_o D) = 127$ X

Problem 4:

A = $M_1\tau_{21}M_2\tau_{12}$

Which the transform matrix τ_{21} is positive and τ_{12} is negative and M_i is reflection matrix from mirror i,

$$A=\begin{bmatrix} -1 & \frac{-2}{r} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 \\ -d & 1 \end{bmatrix} \begin{bmatrix} -1 & \frac{-2}{r} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} -1 & 0 \\ d & 1 \end{bmatrix}$$

A= $\begin{bmatrix} -1 & \frac{-2}{r} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -d & 1 \end{bmatrix} \begin{bmatrix} -1 + \frac{2d}{r} & \frac{2}{r} \\ d & 1 \end{bmatrix}$

A= $\begin{bmatrix} 1 - \frac{6d}{r} + \frac{4d^2}{r^2} & -\frac{4}{r} + \frac{4d^2}{r^2} \\ 2d - \frac{2d^2}{r} & 1 - \frac{2d}{r} \end{bmatrix}$

Now we check the motion after 4 reflection, when d = 1

$A' = M_1 \tau_{21} M_2 \tau_{12} A = A^2$

When d = r:

A = $\begin{bmatrix} 1 - 6 + 4 & -\frac{4}{r_0} + \frac{r}{r} \\ 2d_0 - 2d & -1 \end{bmatrix}$

$A^2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

This means that after four reflection, the beam is in the same starting point.