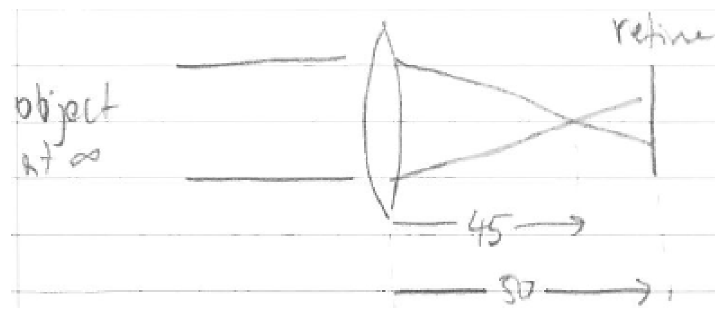
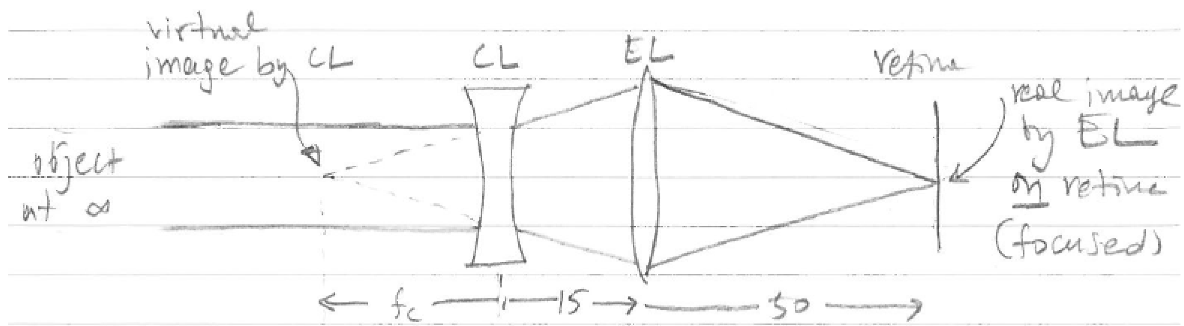
1. (a) Solution: Without correction, the focus is before the retina, leading to blurred vision:



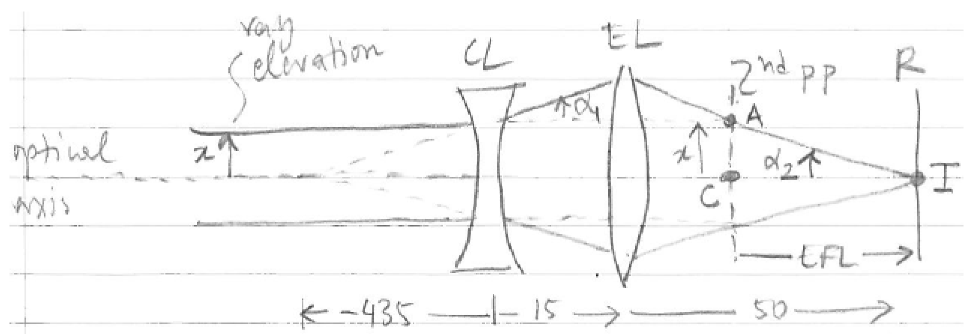
With correction, the image forms (focused) on the retina:



$$\frac{1}{-f_c+15}+\frac{1}{50}=\frac{1}{45}\Rightarrow\frac{1}{-f_c+15}=\frac{1}{45}-\frac{1}{50}=\frac{50-45}{50\times 45}=\frac{5}{50\times 45}$$

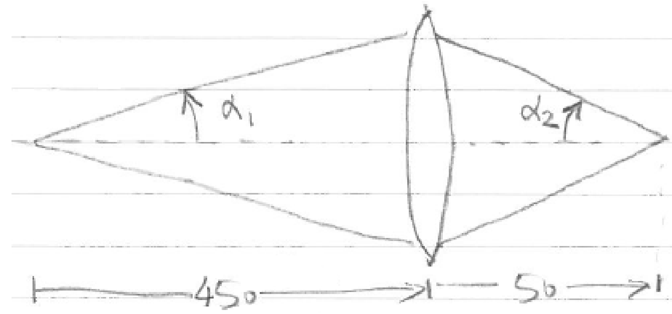
$$-f_c+15=\frac{50\times 45}{5}=450\Rightarrow f_c=-435\quad (P_c\approx -2.3D)$$

(b) Solution: Draw again the ray-tracing diagram for the object at ∞:



$$\alpha_1=-\frac{x}{f_c}=-\frac{x}{-435}=\frac{x}{435}$$

Draw the imaging system formed by EL above, with object = the virtual image found by CL.



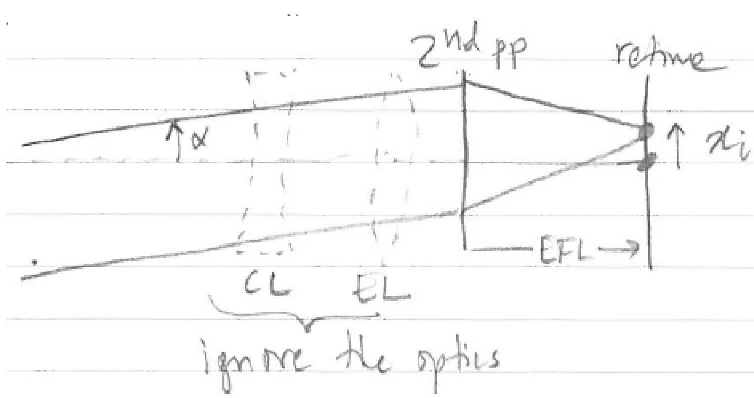
Angular magnification $M_A = -\dfrac{450}{50} = -9$

$$\Rightarrow \alpha_2 = -9 \cdot \alpha_1 = -\frac{9x}{435} = -\frac{x}{48\frac{1}{3}}$$

From △ICA (see diagram on previous page),

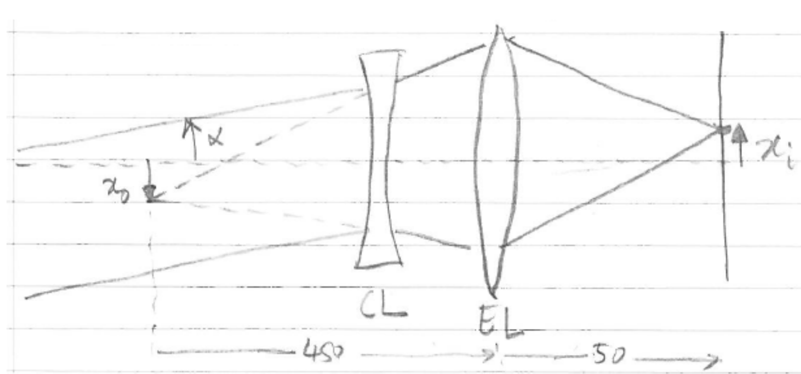
$$\frac{x}{\text{EFL}} = \tan\alpha_2 = \alpha_2 \quad \text{(paraxial approximation)}$$
$$= \frac{x}{48\frac{1}{3}} \Rightarrow \text{EFL} = 48\frac{1}{3}$$

(c) <u>1st method:</u> Using the 2nd PP and EFL



$$x_i = \alpha \cdot (\text{EFL}) = 48\frac{1}{3}\alpha$$

<u>2nd method:</u> Using the imaging condition

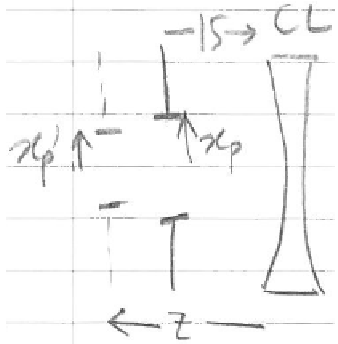


$$x_0 = \alpha f_c = -435\alpha$$

The lateral magnification of EL's imaging system (with the virtual image formed by CL as the object and real image formed on the retina) is given by:

$$M_L = -\frac{50}{450} = -\frac{1}{9} \Rightarrow x_i = M_L x_0 = -\frac{1}{9} \cdot (-435\alpha)$$
$$= \frac{435}{9}\alpha = 48\frac{1}{3}\alpha \Rightarrow \text{Image is } \underline{\text{erect.}}$$

(d) Solution: Use the eye's pupil as the <u>object</u> and <u>flip</u> the optical system for proper ray-tracing.



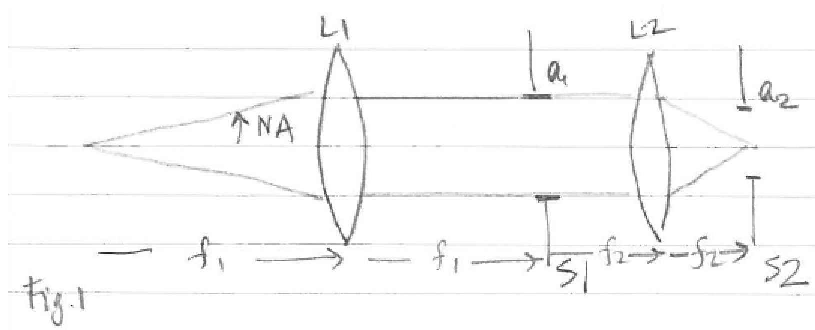
$$\frac{1}{15} + \frac{1}{z} = \frac{1}{-435} \Rightarrow z = -\frac{15 \times 435}{450}$$

$\therefore$ virtual image created as shown

$$\frac{x_p'}{x_p} = M_L = -\frac{z}{15} = \frac{435}{450} = \frac{87}{90}$$

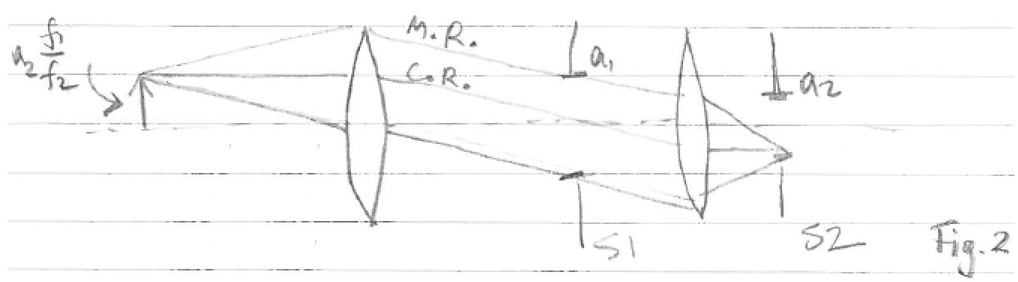
The myopic person's eyes appear <u>smaller</u> and <u>erect.</u>

2. (a) Solution: First consider an on-axis point at the object plane.



$$NA = \frac{a}{f_1}$$

Clearly, S1 limits the angle of acceptance, so S1 is the Aperture Stop. Now consider the chief ray from an off-axis point object.



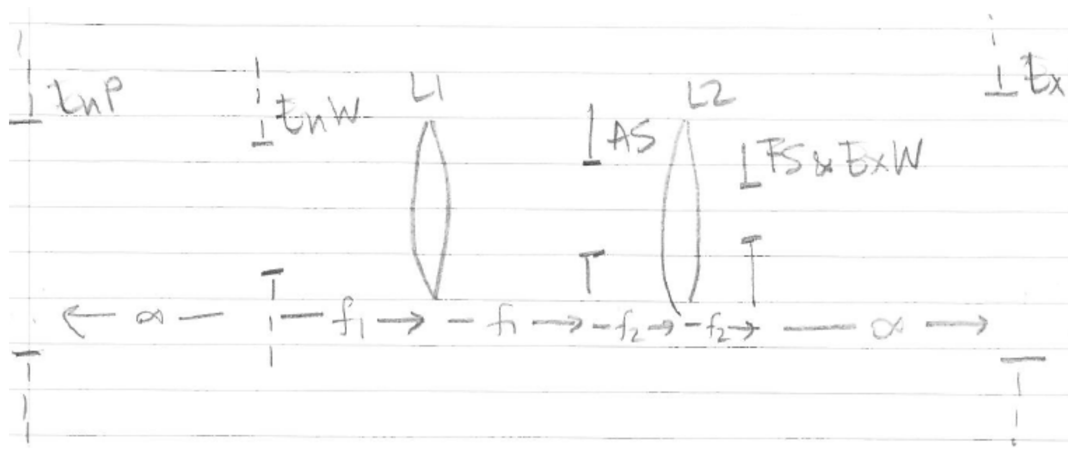
$$\text{FOV} = \frac{a_2 \frac{f_1}{f_2}}{f_1} = \frac{a_2}{f_2}$$

Clearly, S2 limits the chief ray if the point object elevation off-axis becomes sufficiently large, so S2 is the Field Stop.

(b) Solution:

Entrance Pupil:	image S1 through L1	$\Rightarrow \infty$ to the left
Exit Pupil:	image S1 through L2	$\Rightarrow \infty$ to the right
Entrance Window:	image S2 through L2, L1	$\Rightarrow$ object plane
Exit Window:		$\Rightarrow$ collocated with S2

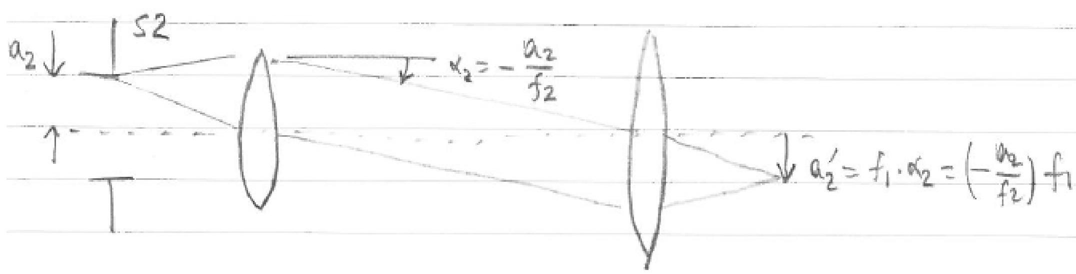
So the completely annotated system is:



(c) Solution: Numerical Aperture & Field of View

From Figure 1, the angle of acceptance is $\text{NA} = \dfrac{a_1}{f_1}$

From Figure 2, S2 is imaged through L2, L1 onto the object plane. The lateral magnification is found as follows:



$$\text{FOV} = \underbrace{\left|\frac{a_2'}{f_1}\right|}_{\substack{\text{limiting angle}\\ \text{of the chief ray}}} = \frac{\frac{a_2}{f_2} f_1}{f_1} = \frac{a_2}{f_2} \quad \text{(half-field)}$$