

Assignment 8

OPTI 502 Optical Design and Instrumentation I

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October 25, 2025

Exercise 1

- a) The blur on the monitor is the tangent of the resolution of the eye times the distance from the eye to the monitor:

$$B_{\text{monitor}} = \tan\left(\frac{1}{60}\right) \cdot 500 \text{ mm} = 0.145 \text{ mm}.$$

The blur on the retina is given by the magnification from the monitor to the eye

$$m = \frac{200 \text{ mm}}{10 \text{ mm}} = 20,$$

times the blur on the monitor:

$$B'_{\text{detector}} = \frac{B_{\text{monitor}}}{m} = \frac{0.145 \text{ mm}}{20} = 0.00727 \text{ mm}.$$

Assuming that the blur equals the pixel size means that the amount of pixels in each dimension is:

$$\text{Width} = \frac{10 \text{ mm}}{0.00727} = 1375.1 \approx 1376 \text{ px}, \quad \text{Height} = \frac{15 \text{ mm}}{0.00727} = 2062.6 \approx 2063 \text{ px}$$

Therefore, the resolution of the system in pixels is 1376×2063 px.

- b) The near distance that meets the blur condition is given $L_{\text{near}} = -2 \text{ m}$. We now use the formula given in the lectures and solve for the F-number:

$$L_{\text{near}} = -\frac{f^2}{2B' f/\#} \rightarrow f/\# = -\frac{f^2}{2B' L_{\text{near}}} = \frac{15.8^2}{2(0.00727)(-2000)} = 8.6.$$

Thus, the F-number must be at least 8.6 to meet the blur condition.

Exercise 2

- a) The reverse telephoto zoom lens is composed of a negative lens L_1 followed by a positive lens L_2 . The overall optical power is given by:

$$\phi = \phi_1 + \phi_2 - \phi_1 \phi_2 \tau = \frac{-1}{f_1} + \frac{1}{f_1} + \frac{1}{f_1^2} t = \frac{1}{f} \rightarrow t = \frac{f_1^2}{f}.$$

The back focal distance is given by the sum of the effective focal length f and the shift of the rear focal distance d' :

$$\text{BFD} = f + d' = f - \frac{\phi_1}{\phi} t = f + 50 \text{ mm.}$$

The system focal length consists of the distance from the first lens to the rear focal point F' :

$$L = t + \text{BFD} = \frac{2500 \text{ mm}^2}{f} + f + 50 \text{ mm.}$$

- b) With the quantities computed in the previous part, we now plot the lens positions with respect to the system focal length L , which gives the location of the fixed image. First, we pick one focal length f , and compute the t distance. Then, we compute the BFD and finally the total length L . The following figure illustrate the position of the lenses relative to the image.

