EC591 Lab 1 Report Notes

1.1A: The beam diverges with a very small divergence angle

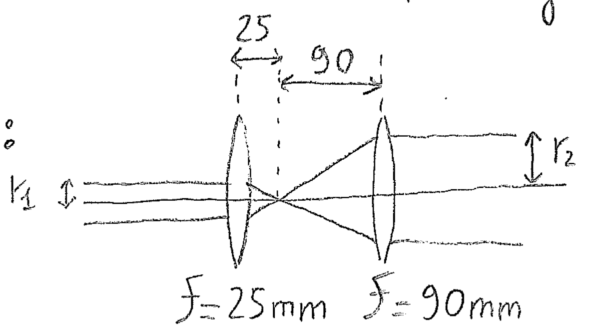
The spot size near the far end of the rail is a few mm

1.1B: $\text{optical power}[W] = \dfrac{\text{photodiode reading}[V]}{\underbrace{\text{responsivity}\left[\frac{A}{W}\right]}_{0.45} \cdot \underbrace{\text{gain}\left[\frac{V}{A}\right]}_{10^4}}$ $\Bigg\{$ usually $\lesssim 1\,mW$

Hazard class: 3a or 2

1.1C: The transmitted power through the polarizer varies as the transmission axis is rotated, but the contrast is well below 100% $\Rightarrow$ the laser light is partially polarized

1.2A:



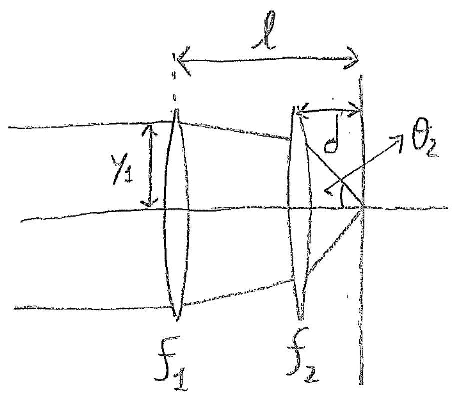
$$\frac{r_1}{25} = \frac{r_2}{90}$$

The beam is expanded by a factor of $\frac{r_2}{r_1} = \frac{90}{25} = 3.6$

The optical power measured after the two lenses is smaller than without the lenses because the beam is larger, and therefore the photodetector (with a small active area $< 1\,mm^2$) intercepts a smaller fraction of the incident light

1.2B: Any observed discrepancy between the measured position of the focus and the expected value may be due to misalignment and/or aberration effects

1.2C:

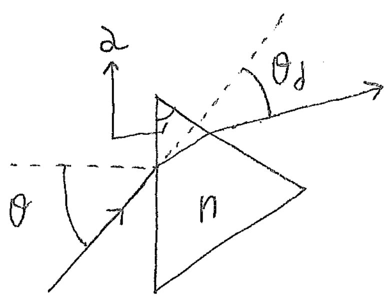


$f_1 = 200$ mm
$f_2 = 65$ mm
$l = 120$ mm

find d

Using matrix optics, $d = 42.5$ mm (see next page)

1.3



$n = 1.51$
$\alpha = 60°$ for an equilateral prism
$\theta = 45°$

From the classnotes $\theta_d = \theta - \alpha + \text{asin}\left[\sqrt{n^2 - \sin^2\theta}\,\sin\alpha - \sin\theta\cos\alpha\right]$

$\Rightarrow \theta_d = 38.3°$

Ray-transfer matrix describing propagation from the immediate left-hand side of lens 1 to the plane of the screen.

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \underbrace{\begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix}}_{\text{propagation from lens 2 to the screen}} \underbrace{\begin{bmatrix} 1 & 0 \\ -1/f_2 & 1 \end{bmatrix}}_{\text{transmission through lens 2}} \underbrace{\begin{bmatrix} 1 & l-d \\ 0 & 1 \end{bmatrix}}_{\text{propagation from lens 1 to lens 2}} \underbrace{\begin{bmatrix} 1 & 0 \\ -1/f_1 & 1 \end{bmatrix}}_{\text{transmission through lens 1}}$$

$$\begin{bmatrix} y_2 \\ \theta_2 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix}$$

$\begin{bmatrix} y_1 \\ \theta_1 \end{bmatrix}$ → rays incident on lens 1

$\theta_1 = 0$ since these rays are // to $\hat{z}$

$\begin{bmatrix} y_2 \\ \theta_2 \end{bmatrix}$ → rays incident on screen

$y_2 = 0$ if these rays are focused on the screen

$$\Rightarrow \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} y_1 \\ 0 \end{bmatrix} = \begin{bmatrix} A y_1 \\ C y_1 \end{bmatrix} = \begin{bmatrix} 0 \\ \theta_2 \end{bmatrix} \Rightarrow A = 0$$

$f_1 = 0.2\,m$

$f_2 = 0.065\,m$

$l = 0.12\,m$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ -\frac{1}{0.065} & 1 \end{bmatrix} \begin{bmatrix} 0.4 + 5d & 0.12 - d \\ -5 & 1 \end{bmatrix} =$$

$$= \begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 0.4 + 5d & \dots \\ -5 - \frac{80}{13} - \frac{1000}{13} d & \dots \end{bmatrix}$$

$$A = 0.4 + \cancel{5d} - \cancel{5d} - \frac{80}{13} d - \frac{1000}{13} d^2 = 0$$

$d = 42.5\,mm$

(+ negative solution)