

Grading: Each quiz counts for 15% of your total grade.

Exam type: Closed-book, all questions can be answered **using only pen and paper**. Calculators are allowed but not necessary for the exam (numerical values will be fractions).

The duration of the quiz is 1 hour.

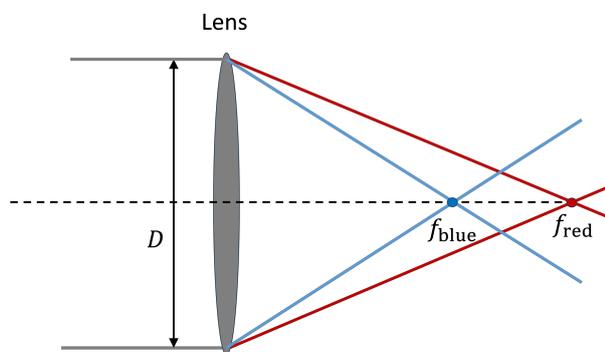
Please fill in all questions listed below. Each of the questions is valued equally in the score calculation of the exam. Please tell if any question is unclear or ambiguous.

Question 1: Dispersion in a thin lens

Assume a thin plastic lens with diameter $D = 5$ mm that focuses collimated red light. The plastic has refraction index $n_{\text{red}} = 1.5 = 3/2$ for red light, focal length $f_{\text{red}} = 10$ mm. The plastic is highly dispersive and the refraction index for blue light is $n_{\text{blue}} = 1.67 = 5/3$. The Lensmaker's formula is valid for the optical system:

$$\frac{1}{f} = (n - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

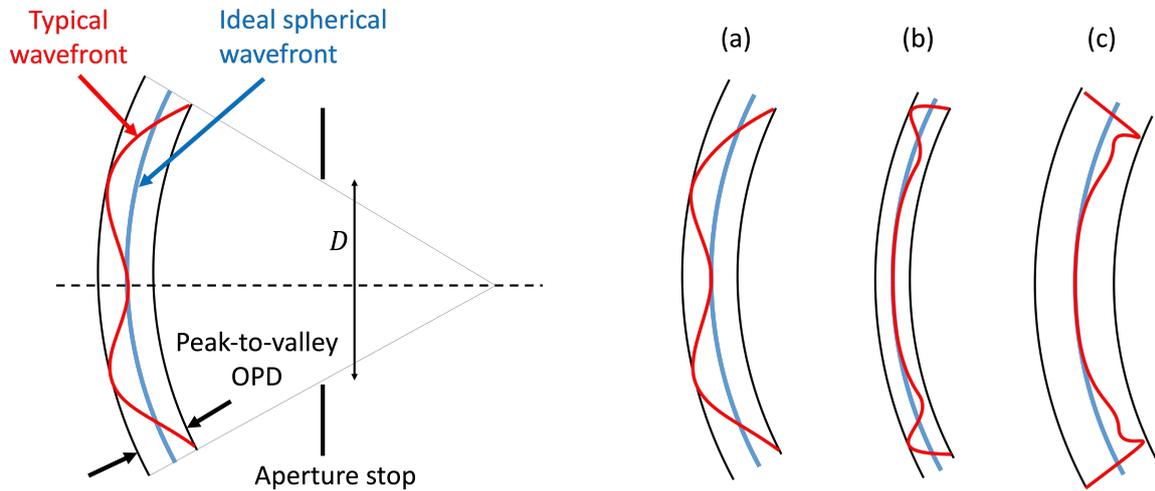
- (a) Derive the focal length for **blue** light: f_{blue} .
- (b) Add a vertical line to the sketch in the figure below where to put the imaging plane as to minimize the spot size due to chromatic aberration?



Question 2: Root Mean Square ODP

Three different optical systems lead to the wavefronts (a), (b) and (c) in below figure. The corresponding Optical Path Differences (ODP), can be quantified by $\text{RMS} = \sqrt{\langle \text{ODP}^2 \rangle}$. The aperture stop is located after the lens and has diameter D .

- (a) Which wavefront has the largest peak-to-valley ODP, and which one has the largest RMS ODP value?
- (b) If you decrease the aperture stop diameter to $D \rightarrow D/2$, which wavefront will afterwards have the largest peak-to-valley ODP? Explain why.



Question 3: Diffraction limit

Consider an optical system existing out of a single thin lens with diameter $D = 10$ mm and focal length $f = 20$ mm. For green incident light ($\lambda = 520$ nm) the airy disk diameter $d = 2.44\lambda f/D = 2.54$ micron.

For this question you can assume that the Lensmaker's formula is valid:

$$\frac{1}{f} = (n - 1) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

- (a) What is the effect on the airy disk diameter d when scaling down the lens by decreasing R_1 , R_2 , and D by a factor 10?
- (b) When only decreasing the lens diameter $D \rightarrow D/10$, what is the resulting value of the airy disk diameter?