Optics, Spring 2024

Submit your answers as a PDF file via Google Classroom before deadline (28.03.2024 at 10.00).

If problems, contact the course assistant joonas.mustonen@helsinki.fi.

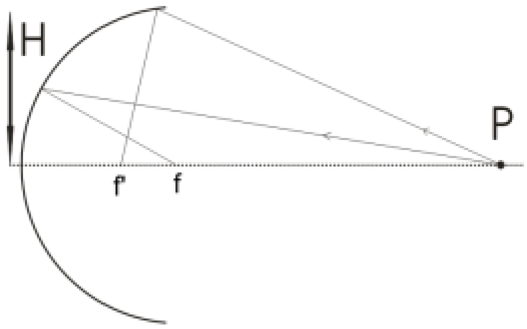
Exercise 8 (Max points 8)

1. Spherical mirrors continued (Ch 5.4) (2p.)

The imaging equation for spherical mirrors with large curvature is:

$$\frac{1}{s_0} + \frac{1}{si} = -\frac{2}{R} - \frac{H^2}{R}\left(\frac{1}{R} - \frac{1}{s_0}\right)^2$$

where H is the height on the mirror (see the figure below). Estimate the amount of spherical aberration by calculating the difference between focal lengths f – f' when the object is in infinity and H << R. Here f and f' correspond to a paraxial ray (parallel to optical axis) and a ray reflecting from the top part of the mirror, respectively. Calculate the difference when H = 8 cm and R = 10 cm.



2. Field of view (Ch 5.7) (2p.)

A rectangular CCD sensor (22.2 mm x 14.8 mm) is placed to the focal plane of the objective lens (f = 1000 mm).

a) Calculate the field of view (FOV) of the arrangement, i.e. the angular diameter of the object at infinity, which corresponds to the CCD sensor size.

b) Is the FOV sufficient for the photography of the Moon (30') or the Andromeda galaxy (90' x 100')?

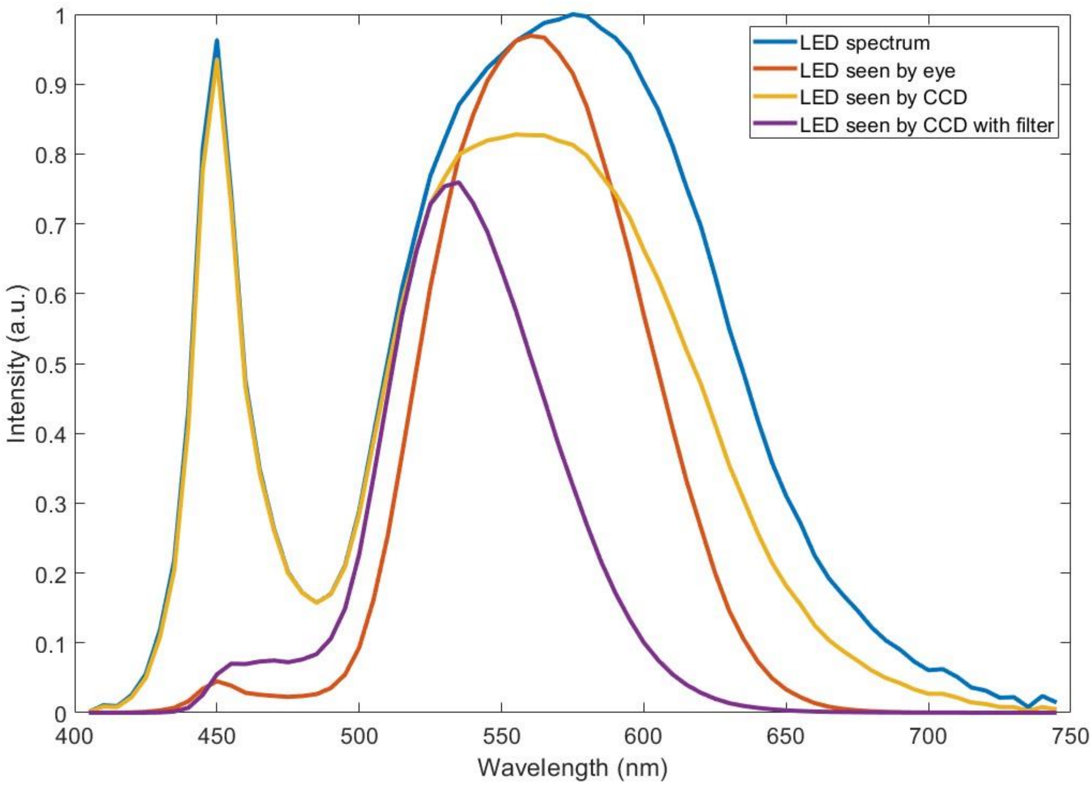
3. Effective spectrum (4p.)

a) Define white LED spectrum and LASER spectrum.

b) Explain physical meaning of convolution in context of impulse response of the measurement device.

c) How does the LED spectrum appear if detected by eye or by a CCD camera?

d) What does happen if a color filter is placed between the LED and the CCD camera?



LED spectrum
LED seen by eye
LED seen by CCD
LED seen by CCD with filter
Intensity (a.u.)
Wavelength (nm)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
400
450
500
550
600
650
700
750