Optics, Spring 2018

Exercise 6, 1.3.2018

1. Field of view (Ch 5.7)

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')?

2. Chromatic aberration (Ch. 5.2)

Due to chromatic aberration, the focal length of a lens depends on wavelength. Assume that focal lengths f_1 and f_2 correspond to refractive indices n_1 and n_2 respectively. Show that, if $n_3 = \frac{n_1+n_2}{2}$ corresponds to focal length $f_3^2 \approx f_1 f_2$, the difference in focal lengths is $f_1 - f_2 = \frac{n_2-n_1}{n_3-1} f_3$.

3. Spherical mirrors (Ch 5.4)

a) A 1-cm tall object is positioned 12 cm in front of a spherical concave mirror having a radius of curvature of 8 cm. Calculate the image location, size, orientation and type. Draw a ray diagram. b) Repeat the calculation for a convex mirror with f = 9 cm. Draw a ray diagram.

4. Mirror magnication (Ch 5.4)

Derive the expression for the transverse magnication of a spherical mirror (concave and convex) in paraxial approximation.

5. Spherical mirrors continued (Ch 5.4)

The imaging equation for large spherical mirrors 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). Estimate the amount of spherical aberration by calculating the difference between focal lengths $f - f'$ when the object is in infinity and $H \ll R$. 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 $R = 10\ cm$.