# Exercise Image Processing

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Sheet 3

In this exercise we will cover the chapters *lens*, *projective motions* and *illumination*. The questions are small-part and can be seen as examples of potential exam problems. Also use the formulary for the exam to complete the tasks.

## Task 3.1: The lens

### 3.1a)

How does the focal length $f$ change if the radii $R_1$ and $R_2$ of the lens remain constant, but a lens material with a larger refractive index $n$ is chosen?

### 3.1b)

For which configuration is the magnification $\beta$ less than one?

- ☐ The object width $g$ is larger than twice the focal length $f$ and the image width $b$ is in the interval $]f; 2f[$.
- ☐ The image width $b$ is larger than twice the focal length $f$ and the object width $g$ is in the interval $]f; 2f[$.
- ☐ The image width $b$ is less than zero, the magnitude of the image width $|b|$ is greater than the object width $g$, and the object width lies in the interval $]0; f[$.
- ☐ The object width $g$ and the image width $b$ are both larger than twice the focal length $f$

### 3.1c)

Using a calculation, explain why the longer the focal length $f$, the larger the aspect ratio $\beta$ for an image distance in the range $f < b < 2f$. What value can the aspect ratio not exceed in this range?

### 3.1d)

How does the focal length $f$ change when the wavelength $\lambda$ of the light becomes shorter? Prove the relationship by an estimation.

3.1e)

Which statements regarding the aspect ratio $\beta$ are correct?

- ☐ The smaller the object distance $g$, the smaller $\beta$.
- ☐ The longer the focal length $f$, the smaller is $\beta$ if the image width is in the range $f < b < 2f$.
- ☐ Every lens has a maximum aspect ratio because below a minimum distance $g_{min}$ it is no longer possible to focus on an object.
- ☐ Every lens has a maximum aspect ratio, because above a maximum distance $g_{max}$ it is no longer possible to focus on an object.

3.1f)

Calculate the working distance $g$ for an image size of $b = 10mm$ and a focal length of $f = 5mm$. What does it follow for the image size $B$ as a function of the object size $G$?

3.1g)

Calculate the depth of field range for a teleradiography for a working distance of $g = 10m$, an aperture of $D = 1cm$, a focal length of $2mm$ and a depth of sharpness of $\epsilon = 1px$. A pixel is square with side length of $s = 10\mu m$.

3.1h)

Assume the model of a thin lens. With a constant focal length $f$, how must the object width $g$ be changed, so that the object is in focus when the image width $b$ increases by $\partial b > 0$, where: $b > f$?

3.1i)

How must the aperture be changed to increase the range of depth of field?

3.1j)

Which two effects have opposite effects on the depth of field when the aperture is varied?

3.1k)

What aberrations can a lens cause?

- ☐ chronic abberation
- ☐ bending blur
- ☐ spherical iteration
- ☐ diffraction blur
- ☐ ternary distortions
- ☐ aspergerismn
- ☐ chromatic abberation
- ☐ diffraction relation

## Task 3.2: Illumination

3.2a)

What is the difference between radiometric and photometric quantities?

3.2b)

What kind of problem can occur on surfaces with directional reflection?

3.2c)

Name two advantages of LED lighting?

3.2d)

What type of illumination can be used to highlight edges of embossed or punched surfaces such as a coin in an image?

3.2e)

What is the difference between incident light and transmitted light?

## Task 3.3: Projective movements

3.3a)

What assumption do you have to make if you want to calculate the ego-motion of a camera from the optical flow?

3.3b)

Determine the calculation formula for the rotation speed $\omega_1$ of a camera around the vertical axis $X$ depending on the flux components $u, v$ and the image point coordinates $x, y$. From which coordinate is the formula independent? If the camera rotates only around the vertical axis, then all translational motion components $\nu_1, \nu_2, \nu_3$ are zero and all other rotational motion components $\omega_2, \omega_3$ as well. The flux component $u = 0$ does not exist.