Example of written examination

(Questions will be provided also in German)

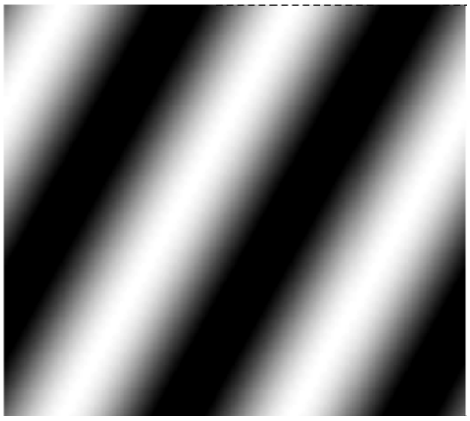
Question	1	2	3	4	5	6	7	8	9	10
Max points	4	6	8	4	9	6	6	6	6	5

X-ray based imaging

Question 1 - Image characteristics (4 points)

1) Sketch the Fourier representation of the following image, explaining the plot (**4 points**)

(it should take 2 minutes)



Question 2 - Image characteristics (6 points)

Define

1) what is the contrast in an image (**2 points**),
2) how it can be improved or deteriorated (**2 points**)
3) and how it is measured in a CT scanner (**2 points**)

(it should take 5 minutes)

Question 3 - X-ray production (8 points)

Sketch and comment the Energy spectrum of X-ray production in the following cases:

1) Source power = 120KV, no filtration, 5 mA current, Tungsten (**2 points**)
2) Source power = 120KV, with filtration, 5 mA current, Tungsten (**2 points**)
3) Source power = 80KV, with filtration, 5 mA current, Tungsten (**2 points**)
4) Source power = 80KV, with filtration, 5 mA current, Molybdenum (**2 points**)

(it should take 4 minutes)

Question 4 – Image formation (4 points)

Two X-ray images are shown below. One corresponds to an X-ray beam with 140 kVp and the other to X-ray beam with 70 kVp. Explain which is which, and the reasons for the differences in image contrast and signal intensity (**4 points**).

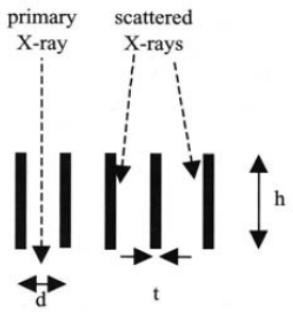
(it should take 2 minutes)

Question 5 – Instrumentation (9 points)

In an X-ray imaging device,

a) where is the anti-scatter grid positioned and what is its role (**2 points**).
b) Has the anti-scatter grid the same function as the filter? (Motivate your answer) (**2 point**s)
c) Let's consider 2 anti-scattering grids, A and B, with the following geometry
   h_a= 5 mm h_b= 5 mm
   d_a= 2 mm d_b= 3 mm
   t_a= 0.1 mm t_b= 0.2 mm

   c.1) What can you say about the final image and dose to the patient? (**3 points**)
   c.2) Which grid would you choose for your system and why? (**2 points**)



(it should take 8 minutes)

Question 6 - Instrumentation (7 points)

As a clinical engineer, you must decide about new equipment in the radiology department. Two vendors propone their own systems:

1) Mobile C-Arm, with Image Intensifier, 30cmx30cm FOV, pixel matrix 512x512, 60 Hz acquisition rate
2) Fixed C-Arm, with Flat panel, 40cmx50cm FOV, pixel matrix 512x512,50 Hz acquisition rate

Write a short report where you compare the 2 systems (**7 points**)

(it should take 5 minutes)

Question 7 – Image reconstruction (6 points)

State the Central slice theorem and explain how it's used for CT image reconstruction (**6 points**)

(it should take 5 minutes)

Ultrasounds (US)

Question 8 – Basic principles (6 points)

a. Write the relationship between the reflection coefficient R and the acoustic impedance Z in case of perpendicular reflection (**1 point**)
b. Compute R at the interface Z_{muscle}-Z_{fat} knowing that the density (ρ) and US speeds are: (**3 points**)
   - $\rho_{muscle}=1.07\ g\cdot cm^{-3}$
   - $\rho_{fat}=0.92\ g\cdot cm^{-3}$
   - $c_{muscle}=1600\ m\cdot s^{-1}$
   - $c_{fat}=1450\ m\cdot s^{-1}$
c. How does US intensity decrease in depth? Explain it by writing the equation and explaining all variables/constants involved (**2 points**)

(it should take 4 minutes)

Question 9 – Instrumentation (6 points)

a. Which kind of "special" amplifier is used in US instrumentation and how does it work? (**1 point**)
b. How can the piezoelectric elements be arranged on the probe and how is the field of view affected? (**4 points**)
c. An US devise has two transducers with different frequencies:
   - Transducer 1, $f_1= 4$ Mhz
   - Transducer 2, $f_2= 24$ Mhz

   Which transducer is ideal to perform measurement on the derma layer and why? (**1 point**)

(it should take 5 minutes)

Question 10 – Image formation (5 points)

a. Explain why pulsed US waves (PW) are preferred to continuous US waves (PW) to build an image and describe the most important parameters (**4 points**)
b. Compute the near field depth of an US beam generated by (f=frequency, D=piezoelement diameter) assuming an average speed in soft tissues of 1540 m/s for
    1. f=2MHz, D= 10 mm
    2. f=2MHz, D= 5 mm
    3. f=4MHz, D= 10 mm
    4. f=4MHz, D= 5 mm

    Comment on the results (**1 point**)

(it should take 5 minutes)