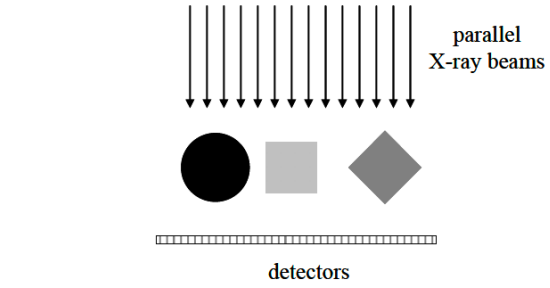
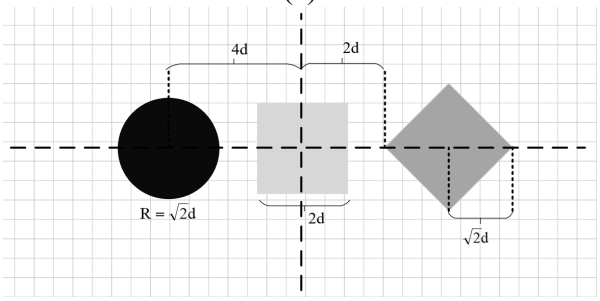
Homework 3

Due: Apr 12th Submit: Blackboard

1. For the object shown in Figure 1(a), a circle and two squares. Draw the projections that would be acquired at angles φ=0, 45, 90, 135 and 180º (ignore beam hardening). Sketch the sinogram for values of φ from 0 to 360º. Assume that a dark area corresponds to an area of high signal. The detail geometry relationship is shown as Figure 1(b).



(a)



(b)

Figure 1

2. For Figure 2, suggest one possible shape that could have produced the sinogram and **explain why**.

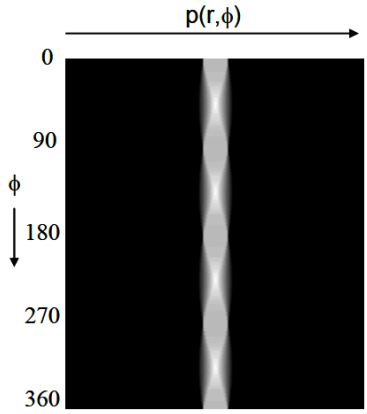


Figure 2

3. Cardiac CT. The following conditions are given:
   - A CT scanner with 128 detector rows.
   - The detector width in the center of the FOV is 0.5 mm.
   - A full rotation (360°) of the X-ray tube takes 0.33 s.
   - A full data set for reconstruction requires projection values for a range of 210°.
   - Maximum 1/4 of the heart cycle can be used for acquiring projection data.
   - The heart rhythm is 72 bpm.
   - The scan length is 20 cm.

   (a) Calculate the duration of 1/4 of heart cycle (in seconds).
   (b) Calculate (in seconds) the time needed to obtain projection values for a range of 210°.
   (c) What can you conclude from (a) and (b)?
   (d) Assume that the table shift per heart beat is equal to the total width of the detector rows (i.e. the total z-collimation). Calculate the acquisition time.
   (e) The assumption under (d) is approximate. Explain why? How does this approximation influence the acquisition time?

4. Window operation. Here is a 10*10 matrix described an image with bone and lung. The values in the matrix are indicated CT number. The original window is set as W=1000 and L=1000, Then,
   (a) Design a window for Bone and calculate the corresponding result after window operation.
   (b) Design a window for lung and calculate the corresponding result after window operation.

			1970	1850	1800	1900			
		1940	1800	1830	1850	1910	1880		
		1880	0	40	60	60	1910		
		1950	20	50	20	40	1800		
		1900	30	0	30	10	1950		
		1910	1800	1920	1900	1840	1890		
			1860	1800	1900	1920			
				1940	1920				

5. Nonlinear partial volume effect

(1) When there is the finite width for the X-ray beam, the averaged attenuation coefficient is counted over the beam width to measure the intensity. The simple example model is shown as below. Please compare the X-ray intensity Ireg and Iavg where μa=(μ1+μ2)/2.

(2) Based on the results from (1), please explain the nonlinear partial volume effect, i.e. considering the finite width of X-ray beam, there will be an underestimation of the integrated averaged attenuation.