

### Project 1

**Instructions:** This project is worth a total of 10 points. You may use any notes or books that you wish but you must work individually. The only computation aid which you may use is MATLAB, unless otherwise indicated. The primary reference for this project is the notes on CT scans which can be found at: <http://www.math.ohio-state.edu/~husen/teaching/571/ct.pdf> Make sure to write clearly and justify your answers.

(1.) For the following, refer to Fig. 1. Suppose that an object is divided into a  $3 \times 3$  grid of square voxels. The length and width of each voxel is 1cm. The scanner which is used consists of three emitters and their corresponding detectors. They are mounted on a ring which surrounds the object. The beams which are produced are parallel and the distance between beam 1 and beam 2 and beam 2 and beam 3 is 1cm. The center of the ring is located at the center of the middle voxel of the object and beam 2 passes through this center. The natural log of the attenuation of each beam is recorded then the ring is rotated 45 degrees clockwise and the natural logs of the attenuations are again recorded. This is repeated twice more and the results are recorded in the following table:

	0 deg.	45 deg.	90 deg.	135 deg.
Beam 1	-1.77	-2.27	-2.27	-2.04
Beam 2	-2.30	-2.10	-1.84	-1.94
Beam 3	-1.89	-1.59	-1.85	-1.98

(a.)(1 pts.) For each column in the table above, determine which voxels each beam will pass through. (Note: there is a total of 12 paths that need to be determined.)

(b.)(1 pts.) Using the information from the table and part (a.), find the set of 12 linear equations which involve the linear attenuation coefficients  $\mu_1, \dots, \mu_9$  for the nine voxels in the object.

(c.)(1 pts.) Write down the augmented matrix which corresponds to the linear system that you found in (b.)

(d.)(3 pts.) Solve this system to determine the linear attenuation coefficients  $\mu_1, \dots, \mu_9$ .

(2.) Continue using the same setup and table from (1.). Previously, we have disregarded the path lengths of the beams through each voxel, but in practice this needs to be taken into account.

(a.)(1 pts.) When the ring is at 0 degrees, beam 1 passes through 3 voxels. What is the length of the path of this beam in each of these voxels?

(b.)(2 pts.) When the ring is at 45 degrees, beam 1 passes through several voxels. What is the length of the path of this beam in each of these voxels? (Round to 2 decimal places). (Note: the length is not the same in each voxel.)

(c.)(1 pts.) Using equation (1.) from the notes (ie. where the lengths are non-trivial), what is the actual attenuation equation for beam 1 when the ring is at 45 degrees? (Round to 4 decimal places)

