CS480/CS680 Problem Set 2

Due in class Monday, September 29 at the beginning of lecture.

Please prepare the answers to these questions, neatly written or typed, on separate paper.

1. (a) (6 points) Write a $3 \times 3$ homogeneous transform matrix $M$ that when applied to a point $(x, y, 1)$ yields $(x', y', 1)$ where $x' = b - 2y$ and $y' = 2x + a$.

   (b) (9 points) In words, what three basic computer graphics transforms occur when we apply $M$ to a point? Give a homogeneous transform matrix for each, and show the order in which they are multiplied.

2. (10 points) Problem 5-2 in the Hearn and Baker text.

3. (15 points) Problem 5-3 in the Hearn and Baker text. Please give all steps in the derivation, as well as multiply out to get the final transform matrix.

4. (20 points) Show that two successive reflections about either the $x$ or $y$ axis is equivalent to a single rotation in the $xy$ plane around the origin. Show this for all possible successive reflections: $x$ reflection followed by $y$ reflection, $x$ followed by $x$, $y$ followed by $x$, etc.

5. (20 points) Problem 5-14 in the Hearn and Baker text.

6. (20 points) We are given a seesaw shown below.

   ![Diagram of a seesaw](image)

   The seesaw rocks (rotates) on its fulcrum at point $C$. The seesaw’s width is denoted $w$. If we apply a rotation of $\theta$ degrees at the seesaw’s fulcrum, the point $P$ moves to a new position, denoted $P'$. Derive the 2D homogeneous transform $M$, such that $P' = MP$.

7. (CS680 required 20 points, CS480 extra credit 10 points) We can specify a 2D pivot-point rotation by considering the location of a small number of points before and after the points have rotated. How many points are needed to specify the transform uniquely? Are there any special conditions that these points must satisfy? Give the mathematical expression for computing the 2D rotation matrix $R$ given such a set of points.