CS 465 Midterm 1

Wednesday 4 October 2006—50 minutes

Problem 1: 2D Transformations (40 pts)

Each of the transformations specified by the following 2D homogeneous matrices falls into one or more of the following classes:

(a) translation;

(b) scale about the origin, aligned with the canonical axes;

(c) rotation about the origin;

(d) mirror reflection about an axis through the origin;

(e) shear about the origin, along one of the canonical axes.

For each transformation, list *all* the classes it belongs to.

Example: $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 1. $\begin{bmatrix} -1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 2. $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

3. $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 4. $\begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 5. $\begin{bmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 6. $\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

The answer to the example is “a, b, c, and e”.

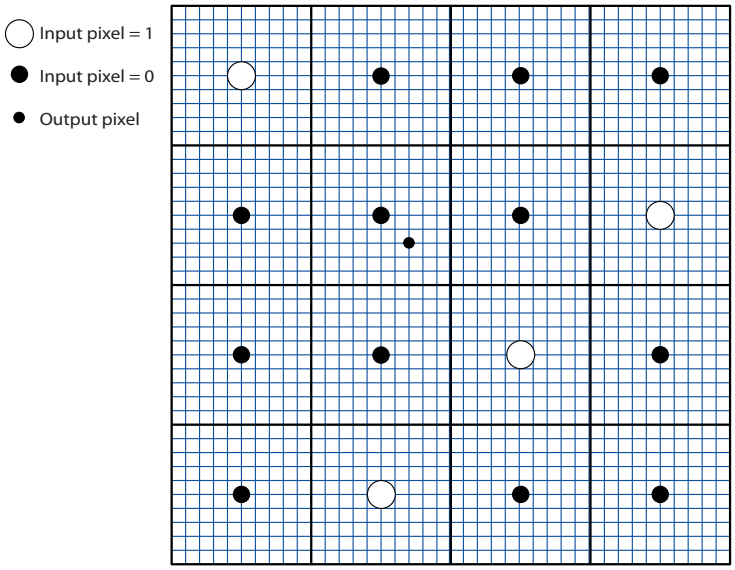
Each of the following transformations can be expressed as a sequence of two or more transformations from the classes given above. Find *one* way that each matrix can be made this way, and describe the transformations.

Example: $\begin{bmatrix} 2 & 0 & 3 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 7. $\begin{bmatrix} 0 & -2 & 0 \\ 2 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ 8. $\begin{bmatrix} 3 & 1 & 0 \\ 1 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

An answer to the example is “nonuniform scale by 2 in x and 1 in y followed by a translation by 3 in x.” *Hint:* To get a sense for what a transformation does, you can transform the four corners of the unit square.

Problem 2: Resampling (30 pts)

The following diagram shows a 4 x 4 pixel area of an image that is being resampled, with the location of one output sample marked.



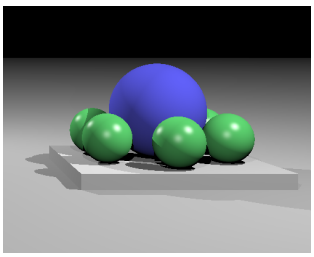
Compute the value of the output pixel using each of the following filters.

1. A box with support radius 0.5.
2. A tent with support radius 1.
3. A B-spline cubic with support radius 2.

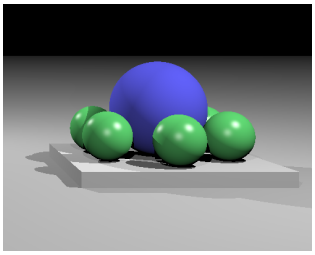
The following values of the B-spline filter suffice for this problem:

t	$f(t)$
0/10	8000/6000
2/10	5832/6000
4/10	4096/6000
6/10	2744/6000
8/10	1728/6000
10/10	1000/6000
12/10	512/6000
14/10	216/6000
16/10	64/6000
18/10	8/6000
20/10	0/6000

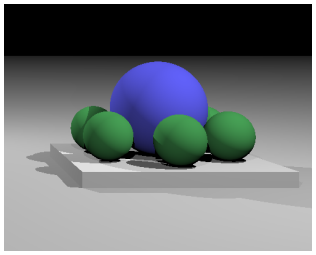
Problem 3: Ray tracing bugs (30 pts)



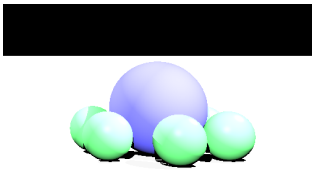
Below are eight renderings of a simple scene, produced by a ray tracer in various states of disrepair. Your job is to match the bugs listed below with the corresponding incorrect outputs. For example, the image labeled "Example" matches the bug "You forget to normalize the surface normals when you compute them for spheres."



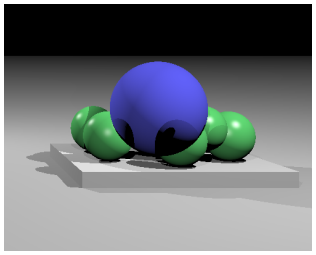
Correct



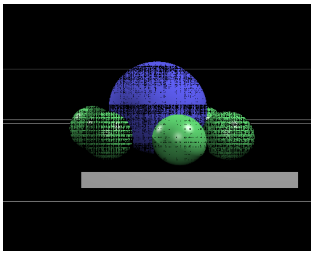
Example



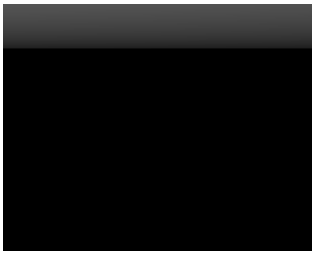
A



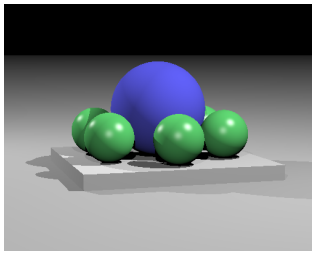
B



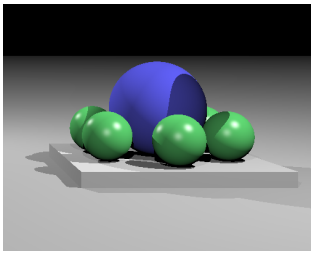
C



D



E



F

0. *Example*: You forget to normalize the surface normals when you compute them for spheres.
1. You accidentally swap the viewpoint with the image plane point in the camera code.
2. You start your shadow rays exactly at the reflection point.

3. You forget to normalize the eye and light direction before computing Lambertian shading.
4. Rather than checking all the objects to find the closest intersection along a viewing ray, your intersection method always returns the first one that is found.
5. You accidentally use the view direction for the image plane normal, leaving the supplied image plane normal unused.
6. When you detect a shadow ray intersection, you neglect to check that it happened between the shading point and the light.

These are the same bugs as on Homework 2, but the model is different (it is not an enclosure).