University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Final Examination
Thursday, December 8, 2011

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Name:_____

Please write your name or initials at the top of every page before beginning the exam.

Please include all steps of your derivations in your answers to show your understanding of the problem. Try not to write more than the recommended amount of text. If your answer is a mix of correct and substantially wrong arguments we will consider deducting points for incorrect statements. You may not use calculators, notes, textbooks or other materials during this exam, except for one double sided, hand-written 3x5 inch index card. There are ten questions for a total score of 100 points.

Good luck!

This space is for grading

Exercise	Points
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total	

1) Transformations (10 Points)

Given is a line segment in the xy plane with endpoints at $p_1 = (0, 0)$ and $p_2 = (5, 0)$. Determine a transformation matrix T that transforms it into a line segment with endpoints at $p_1' = (5, 1)$ and $p_2' = (8, 5)$. Use **either** an algebraic approach **or** a geometric approach.

- The **algebraic** approach is to set up a system of equations for the x and y coordinates of the points before and after transformation, using this form for the matrix:

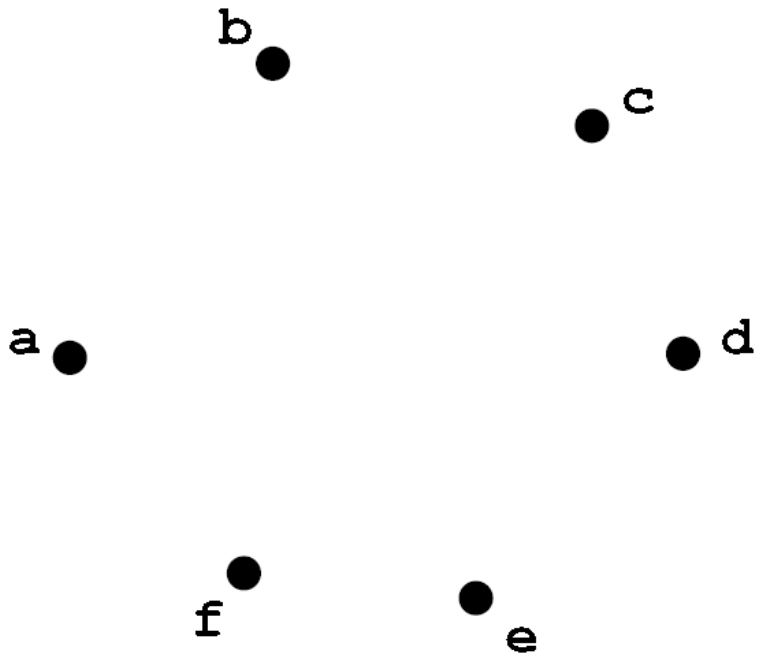
  $$\begin{bmatrix} a & b & c \\ -b & a & d \\ 0 & 0 & 1 \end{bmatrix}$$

  This will yield four equations (two points times two coordinates) in four unknowns (a, b, c, d). In this case, report the **values of a, b, c and d**.

- The **geometric** approach is to inspect the four points, identify a rotation that will make the segment p_1p_2 parallel to $p_1'p_2'$, and then identify a translation that will make the two segments coincident. Hint: a 3-4-5 right triangle has interior angles of 36.87 degrees, 53.13 degrees, and 90 degrees. In this case, report the **translation vector and the angle of rotation**.

2) Parametric Curves (10 Points)

The figure below contains points for two Bezier curves specified by points (f, a, b, c) and (c, d, e, f).



a) What is the degree of the Bezier curves? (1 point)

b) Sketch the evaluation of the Bezier curve (f, a, b, c) at (approximately) t=0.25 using the de Casteljau algorithm. (3 points)

c) Are the curves **C0** continuous at points f and c? (1 point)

d) Are the curves **C1** continuous at points f and c? (1 point)

e) Sketch the convex hull of the control points of Bezier curve (c, d, e, f). (2 point)

f) List the two main disadvantages of Bezier curves, which are overcome by NURBS curves. (2 points)

3) Parametric Surfaces (10 Points)

A bilinear patch x(u, v) is given by four control points

$p_0 = (2, 0, 1)$
$p_1 = (4, 2, 1)$
$p_2 = (2, 2, 0)$
$p_3 = (7, 4, 5)$

and $x(0, 0) = p_0$, $x(1, 0) = p_1$, $x(0, 1) = p_2$, and $x(1, 1) = p_3$.

a) Evaluate the patch at (u, v) = (0.2, 0.5). (5 points)

b) Compute the tangent vectors and the normal at this point. (5 points)

4) Environment Mapping (10 Points)

a) Name two goals of environment mapping? (2 points)

b) Name two requirements on the scene for environment mapping to work well. (2 points)

c) Name two ways to create environment maps. (2 points)

d) Name two advantages of cube maps over spherical environment maps. (2 points)

e) Why is it computationally more expensive to compute shading of a diffuse surface than of a specular surface when an environment map is used? (1 point)

f) Name a technique to speed up the rendering of diffuse surfaces with environment maps. (1 point)

5) Toon Shading (10 Points)

a) What is the goal of toon shading? (2 points)

b) How can toon shading be accomplished in real-time? (2 points)

c) Explain how silhouette edges can be detected for toon shading. (4 points)

d) Name two parameters the programmer can tweak the toon shading algorithm with. (2 points)

6) Shadow Mapping (10 Points)

a) Describe the shadow mapping algorithm using a sketch and a few explanatory sentences. (6 points)

b) List two potential problems or artifacts that may appear with shadow mapping, and suggest solutions. (4 points)

7) L-Systems (10 Points)

An L-system has the following parameters:

- Variables: X Y
- Constants: F + -
- Start string: FX
- Rules: (X → X+YF), (Y → FX-Y)

Here, F means “draw forward”, - means “turn left 90°”, and + means “turn right 90°”. X and Y do not correspond to any drawing action and are only used to control the evolution of the curve.

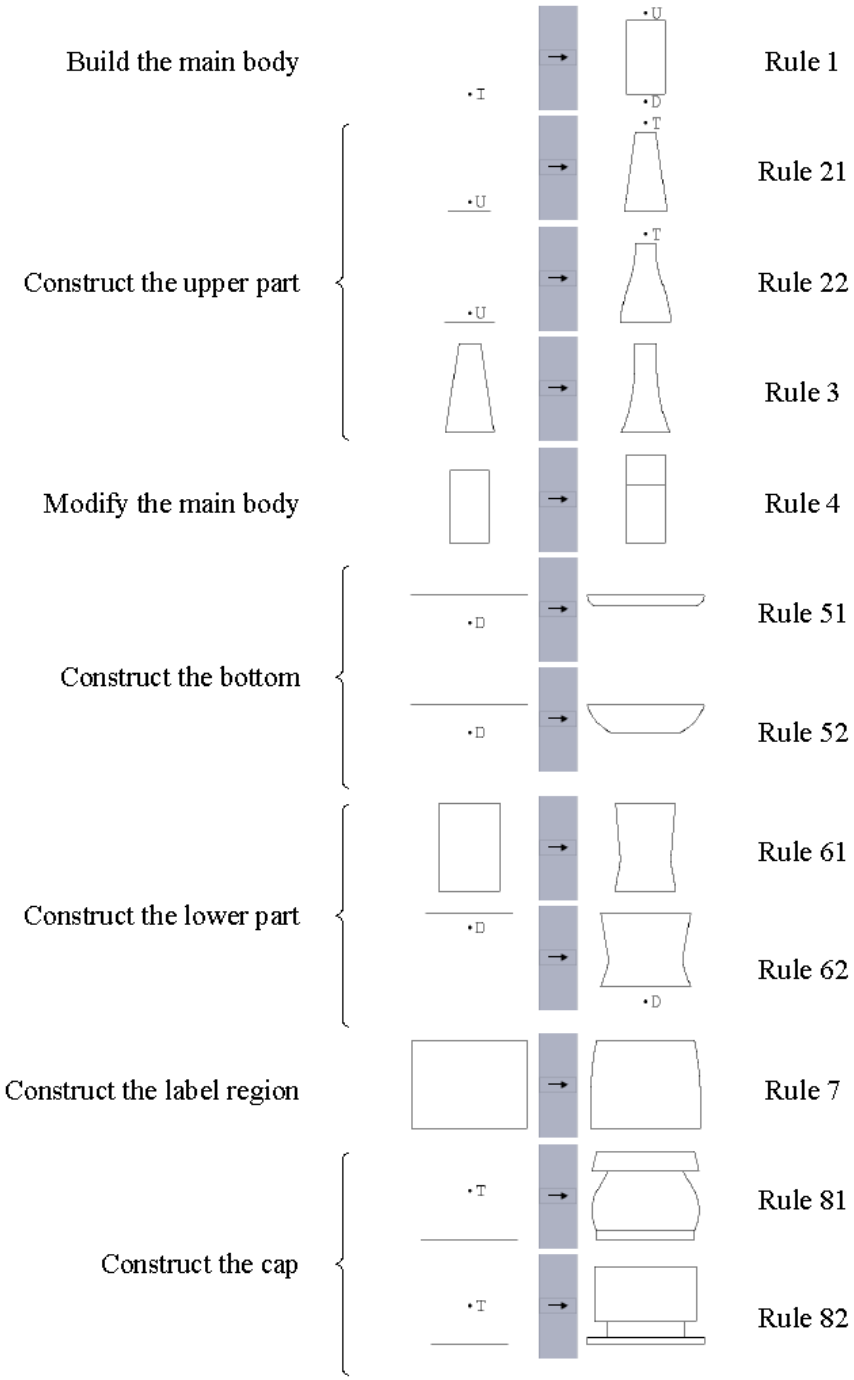
Hint: The first level of recursion is: FX+YF.

a) Generate the strings for the second and third level of recursion (5 points).

b) Draw the curves for the second and third levels of recursion (5 points).

8) Shape Grammar (10 Points)

Given the following shape grammar:



On the next page, draw each step in the evolution of a shape when the following rules are applied in the given order on starting shape • I

Rule 1, 22, 51, 81, 4, 7, 61

Space for problem #8

9) Particle Systems (10 Points)

a) Name three examples for what particle systems are good at modeling. (1.5 points)

b) What is the difference between random and pseudo-random numbers? Name one example each where this type of random number is useful. (2 points)

c) What is the purpose of the particle emitter, and what shapes can it have? (2 points)

d) Name three typical attributes of the particles in a particle system. (1.5 points)

e) At the beginning of each frame, a particle system updates its parameters. Name two examples for attributes of the particle system which typically are updated every frame, and the strategy for the update. (2 points)

f) Name two examples for primitives used to render particles of a particle system. (1 point)

10) Volume Rendering (10 Points)

a) What is the difference between surface rendering and volume rendering? (2 points)

b) Name two scientific disciplines in which volume rendering is used. (2 points)

c) What is a voxel? Name an example for what kind of data it contains. (2 points)

d) What is the difference between direct volume rendering and other volume rendering approaches? (2 points)

e) In direct volume rendering, what is the benefit of using 3D textures compared to 2D textures for the storage of the volume data set? (2 points)