University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Instructor: Dr. Jürgen P. Schulze

Midterm Examination
Thursday, November 29, 2012

Name:_____

- Please write your answers on these sheets and include all steps of your derivations in your answers.
- Simplify terms with numbers as much as possible without a calculator.
- Complete sentences are not expected; bullet items or simplified sentences are fine.
- If your answer is a mix of correct and 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!

Do not write below this line

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:

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

  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**.

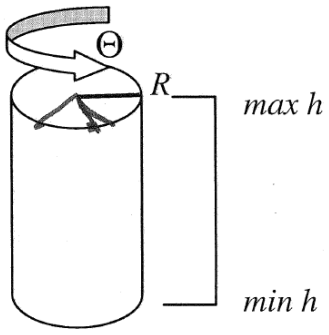
- The **geometric** approach is to inspect the four points, identify a rotation that will make the segment p_1p_2 parallel to $p_1'p_2'$, and then identify a translation that will make the two segments coincident. Hint: a 3-4-5 right triangle has interior angles of 36.87 degrees, 53.13 degrees, and 90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

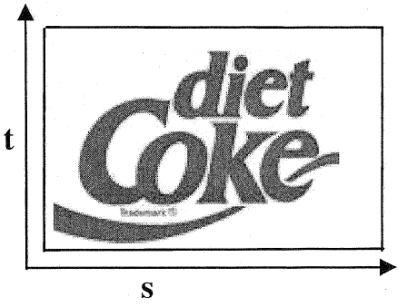
2. Texture Mapping (10 Points)

You are given the task of putting the diet Coke label on the 2 liter bottle as shown (it only goes 25% around the bottle and is positioned as shown). The bottle has two parts: a cylindrical bottom and a conical top. The bottom of the label should be half-way up the cylindrical part of the bottle, and its height should be 25% of the height of the cylindrical part of the bottle. What are the texture coordinates which perform this operation? (In other words: express *s* and *t* as functions of *min h*, *max h*, *h* and *θ*)

Be sure to describe any assumptions you make. Although the texture is not square, you can assume the range in *s* and *t* is [0..1].

$$x = R\cos(\Theta)$$
$$y = R\sin(\Theta)$$
$$z = h$$





3. Parametric Object (10 Points)

Given a cone that has its apex at $(0, 0, 3)$, and whose intersection with the xy-plane is a unit circle.

a) Write a parametric equation of the form $\mathbf{p}(u, v)$ to describe the surface of this cone. Remember that $\mathbf{p}(u, v)$ consists of three functions $x(u, v)$, $y(u, v)$ and $z(u, v)$. The curve $\mathbf{p}(u, 0), u \in [0..1]$ should map to a unit circle in the xy-plane, and $\mathbf{p}(u, 1), u \in [0..1]$ should be the apex. (6 points)

b) Derive equations for two tangent vectors and the normal at any point (u, v). You do not need to normalize the normal vector to unit length. (4 points)

4. Bilinear Surface Patch (10 Points)

A bilinear surface patch is specified by four control points $p_{(0,0)} = (0, 0, 0)$, $p_{(1,0)} = (6, 0, 6)$, $p_{(0,1)} = (2, 4, 4)$, and $p_{(1,1)} = (5, 4, 4)$.

a) Write down an equation of the form x(u, v) that computes a point x on the surface patch given parameter values $0 < u,v < 1$, and simplify the equation. (5 points)

b) Compute two tangent vectors and the unit surface normal at $(u, v) = (\frac{2}{3}, \frac{1}{2})$. Evaluate these vectors numerically. (5 points)

5. Environment Mapping (10 Points)

a) What is an environment map? (2 points)

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

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

d) Is it computationally more expensive to compute shading of a diffuse surface or a specular surface when an environment map is used? Why? (2 points)

e) Name a technique to speed up the rendering of diffuse surfaces with environment maps. Explain its basic idea in one sentence. (2 points)

6. Toon Shading (10 Points)

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

b) What other name is toon shading known as and where does this name come from? (2 points)

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

d) Explain how silhouette edges can be detected for toon shading. (2 points)

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

7. Shadow Mapping (10 Points)

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

b) Name and describe in a few words two potential problems or artifacts that may appear with shadow mapping. (4 points)

8. L-Systems (10 Points)

An L-system has the following parameters:

- Variables: F
- Constants: + -
- Start string: F
- Rule: F → F+F-F-F+F

Here, F means “draw forward”, + means “turn left 90°”, and - means “turn right 90°”. The initial orientation of the “turtle” is “right”.

Hint: Level 0 of the recursion is: F

a) Generate the strings for levels one and two of the recursion (6 points).

b) Draw the curves for level 0, 1 and 2 of the recursion. (4 points)

9. Particle Effects (10 Points)

a) Name two examples for what particle systems are good at modeling. (2 points)

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

c) Name four typical attributes of the particles in a particle system. (2 points)

d) 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)

e) Name two examples for primitives used to render particles of a particle system. (2 points)

10. Collision Detection (10 Points)

a) What is the goal of collision detection? Explain with an example. (2 points)

b) Name two reasons why correct collision detection can be computationally expensive even with moderate amounts of 3D objects? (2 points)

c) What is the goal of the Sweep and Prune algorithm? How does it work? Only explain the case of dimension reduction to one dimension. (4 points)

d) Name and briefly explain another collision detection algorithm. (2 points)