University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Midterm Examination #2
Thursday, November 20th, 2013
Instructor: Dr. Jürgen P. Schulze

Name:_____

Please put your name or initials at the top of every sheet before beginning the exam so that we don't have to guess when we find loose sheets.

Your answers to the exam questions must include your derivations.

This is a closed book exam. You may not use electronic devices, notes, textbooks or other written materials.

There are ten questions with a maximum 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. 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.

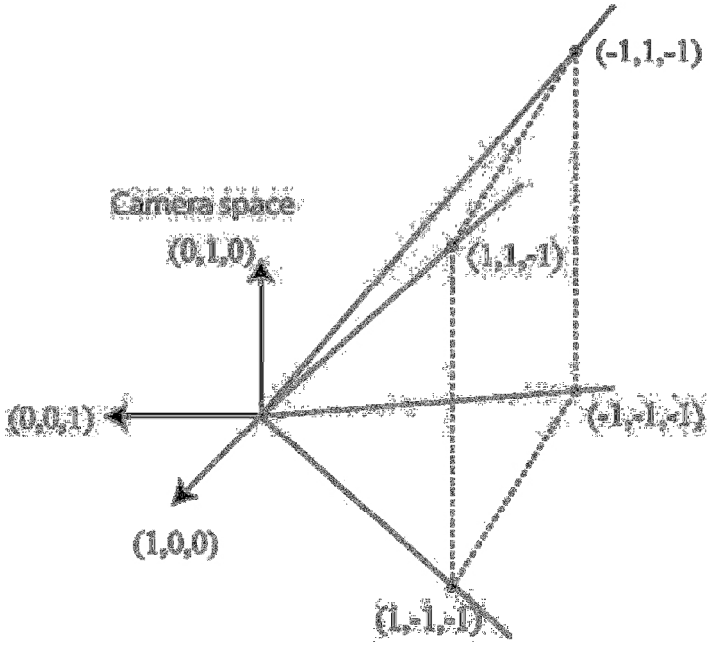
a) Write a parametric equation of the form $\mathbf{p}(u, v)$ to describe the surface of this cone. Remember that $\mathbf{p}(u, v)$ consists of three functions x(u, v), y(u, v) and z(u, v). The curve $\mathbf{p}(u, 0), u \in [0..1]$ should map to a unit circle in the xy-plane, and $\mathbf{p}(u, 1),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

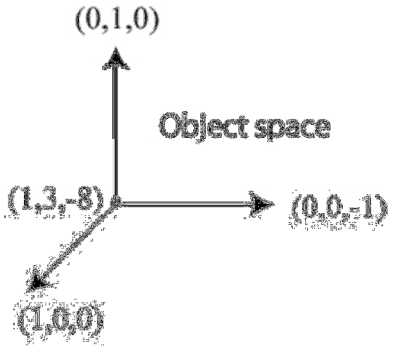
b) Derive equations for two tangent vectors and the normal at any point (u, v). You do not need to normalize the normal vector to unit length. (4 points)

2. View Frustum Culling (10 points)

Given the perspective view frustum shown in the figure below. The top bounding plane of the view frustum is determined by the plane going through the points (0, 0, 0), (1, 1,–1), and (–1, 1,–1) in camera coordinates. Note that the other bounding planes will not be relevant to this problem. In addition, there is an object coordinate system defined by basis vectors (0, 1, 0), (1, 0, 0), (0, 0,–1) and the origin (1, 3,–8) in camera coordinates. Note that the order of the basis vectors matters!

Assume there is an object with a bounding sphere with radius 2 centered at (8, 1, 1) in object coordinates. Determine if this bounding sphere intersects with the top bounding plane of the view frustum. You should do this by transforming the center of the bounding sphere from object to camera coordinates. Then you need to compute the distance from the bounding sphere center in camera coordinates to the top bounding plane.





3. Texture Mapping (10 Points)

As you know, texture mapping is used to make simple polygon models look more realistic without having to create millions of polygons with different colors. In this question, we will discuss some of the implementation details for texture mapping. Assume that you are given the following image of the diet coke logo, and your task is to texture map this im age onto a cylinder, so you can have diet coke cans in your graphics scene.

a) How would you break your cylinder model into N polygons? Draw a diagram that shows a side view of your cylinder to illustrate your polygon model.

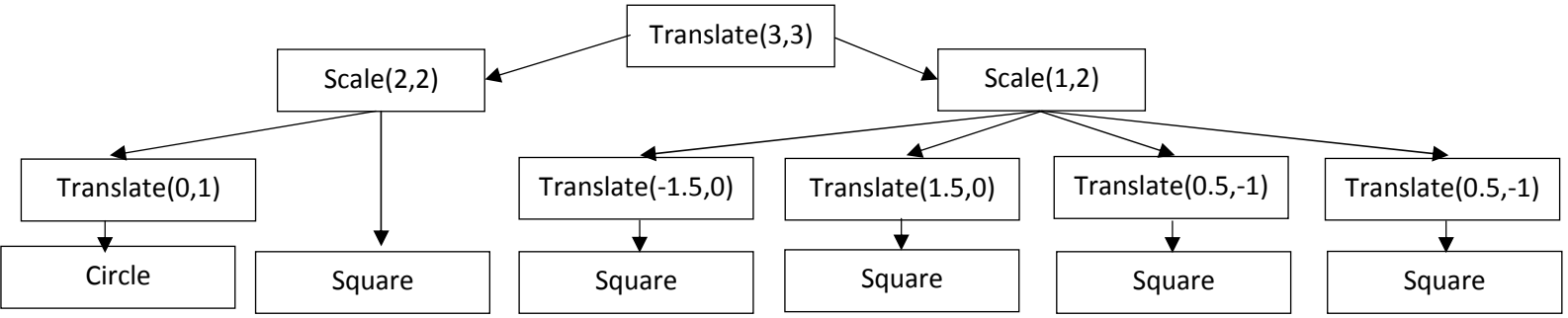
b) How you would map the texture onto these polygons? Be specific about how you would map polygon coordinates into texture coordinates. Where do you specify this mapping in a typical OpenGL texture mapping application?

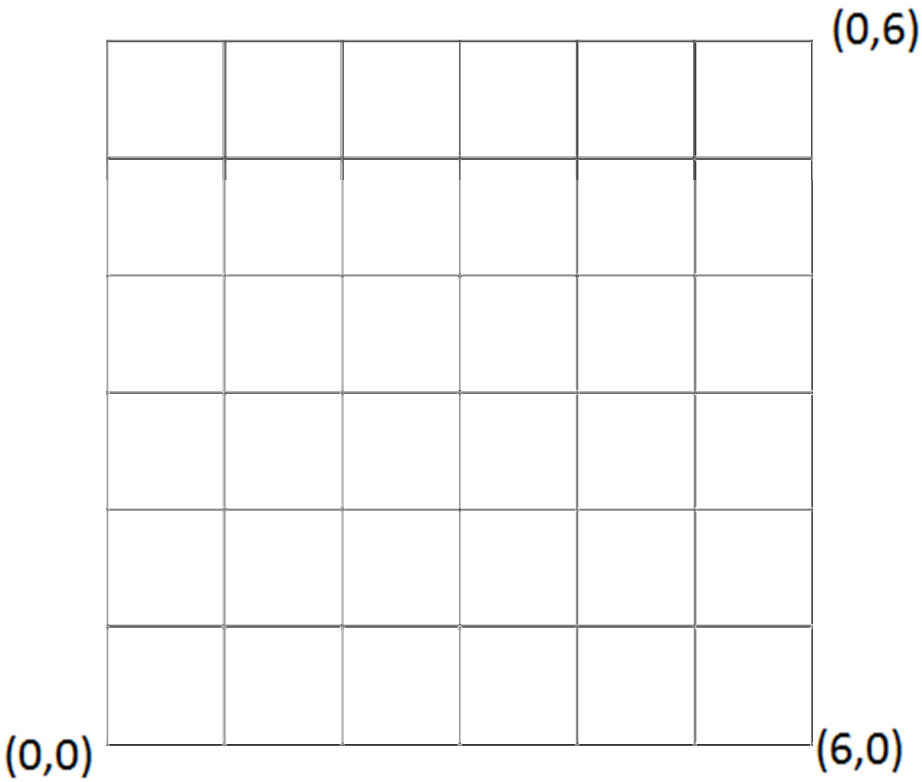
c) What happens if the polygon in your image is larger than your texture map image? How are the pixel color values calculated for the polygon?

4. Scene Graph (10 Points)

Transformations	**Primitives**
Translate(x,y) – translates to point (x,y). Scale(sx,sy) – scale by factors sx and sy.	Circle – centered at the origin with radius 1 Square – centered at origin with side length 1

a) Draw the robot figure that this scene graph structure represents. (6 points, 1 for each shape)





b) Modify the scene graph to put a disk in the robot's hand. Use a Circle primitive for the disk, and draw your modification on the current scene graph. Your modification must keep the disk in the robot's hand under any arm transformation. (4 points)

5. Joining Curves (10 Points)

Equations of two curves Q and R are given as follows:

$Q(t) = (1 + t^2)P_1 + (5t – 5t^2)P_2 + t^2P_3$.

$R(t) = (1 + t^2)P_3 + (5t – 5t^2)P_4 + t^2P_5$.

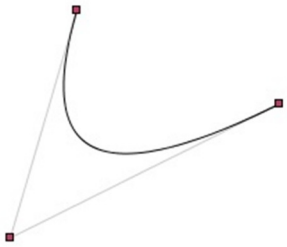
For both the curves $0 <= t <= 1$. P_n are the control points.

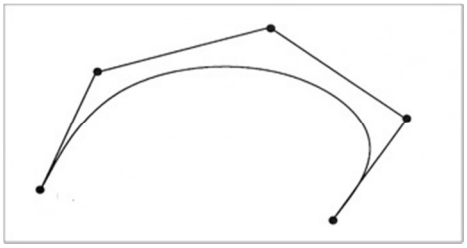
a) Are both the curves C_0 continuous at Q(1) and R(0)? Explain. (5 points)

b) Are they both C_1 continuous at Q(1) and R(0)? Explain. (5 points)

6. Bezier Curves (10 Points)

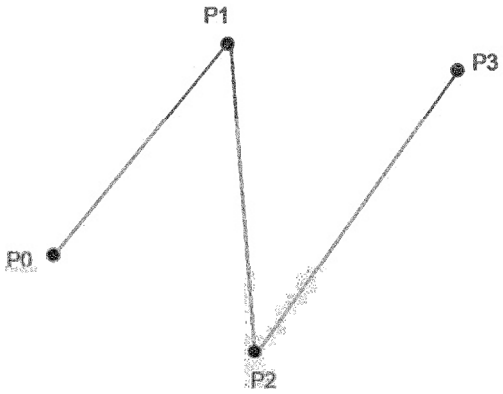
a) Give the order (degree) of each of the following curves: (1 point)





b) If the number of control points that define a curve is *n,* what is the order of the curve in terms of n? (1 point)

c) Given to you is a Bezier Curve's 4 control points P_0, P_1, P_2 *and* P_3. (Note the order in which they are given!). Use the De Casteljau algorithm to find a point S (approximately) on the curve for values of: **t = 0.2, t = 0.5 and t = 0.75**
You need to use Linear Interpolation to find the points Q_0, Q_1, Q_2, R_0, R_1 *and S.* **Draw** one diagram (total 3) for each of the above values of t.
Now, take a look at the points that you have obtained, and try to approximately draw the shape of the curve (in a separate diagram) (8 points)



7. Toon Shading (10 Points)

a) Why is toon shading also called Cel Shading? What does Cel Shading stand for? (2 points)

b) Which two visual effects does tool shading use to give images a cartoon-style look? (2 points)

c) Explain how the toon shading algorithm detects silhouette edges. (6 points)

8. Environment Mapping (10 Points)

a) Which two geometries for environment maps did we discuss in class? Name one advantage for each of them that it has over the other. (4 points)

b) With environment mapping, is it easier to render shiny or diffuse shapes? Explain why. (4 points)

c) What is a Diffuse Irradiance Environment Map used for? (2 points)

9. Shadow Mapping (10 Points)

a) Briefly define the following terms in the context of shadow rendering: (1 point each)
   a. Occluder

   b. Receiver

   c. Umbra

   d. Penumbra

b) Name the shape of a light source which would produce a hard shadow. (1 point)

c) Name the shape of a light source which would produce a soft shadow. (1 point)

d) In the shadow mapping algorithm, why is the camera moved to the position of the light source? (2 points)

e) If you implemented the shadow mapping algorithm, but your shadow shows stair-stepping artifacts: how can you reduce the artifacts? Name two approaches to mitigate the effect. (2 points)

10. Shadow Volumes (10 Points)

a) How are the silhouette edges detected, which form the beginning of the shadow volume? (4 points)\

b) What role does the stencil buffer play for shadow volumes? (3 points)

c) Given a shadow volume implementation with an 8-bit stencil buffer. In the image below, for each separate area write the number stored in the stencil buffer for it. (3 points)