University of California San Diego
Department of Computer Science
CSE167: Introduction to Computer Graphics
Fall Quarter 2014
Midterm Examination #2
Tuesday, December 2nd, 2014
Instructor: Dr. Jürgen P. Schulze

Name:_____

Your answers must include all steps of your derivations, or points will be deducted.

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

Good luck!

Do not write below this line

Exercise	Max.	Points
1	12	
2	10	
3	8	
4	10	
5	10	
6	10	
7	10	
8	10	
Total	80	

1) Shading (12 Points)

In Homework Assignment #3 you were responsible for producing some simple diffuse shading on the CPU.

Given:

Vertex:	<1, 1, 1>
Normal:	<1, 2, 3>
Light position:	<3, 7, 9>
Light brightness:	10.0
Material color:	<0.2, 0.3, 0.7>
Light color:	<0.5, 0.2, 0.9>
Model matrix:	| 2 0 0 1 |
	| 0 2 0 2 |
	| 0 0 2 3 |
	| 0 0 0 1 |

Find:

Vertex in world coordinates: < , , > (1 point)

Normal in word coordinates: < , , > (1 point)

Vector from vertex to light: < , , > (1 point)

Distance to light: (1 point)

Normalized world normal: < , , > (1 point)

Normalized vertex to light: < , , > (1 point)

A scale factor was used for each coordinate in the resulting color vector. Write down that equation (values not needed, just variables). (3 points)

Given brightness, color of the light, and material color, what will be the final color obtained after shading? (values not needed, just variables). (3 points)

2) Parametric Curves (10 Points)

Consider the two points $\mathbf{P_0}$ and $\mathbf{P_1}$ as below. There exists another point Q that lies on the straight line connecting $\mathbf{P_0}$ and $\mathbf{P_1}$.

a) Write a relation to represent **Q** in terms of $\mathbf{P_0}$, $\mathbf{P_1}$ and a parameter **t**. (4 points)

b) What are the two values of **t** at which Q would equal $\mathbf{P_0}$ and $\mathbf{P_1}$? (2 points)

c) From the relation above, find the tangent at **Q**. Does the tangent vary at every **Q**? (4 points)

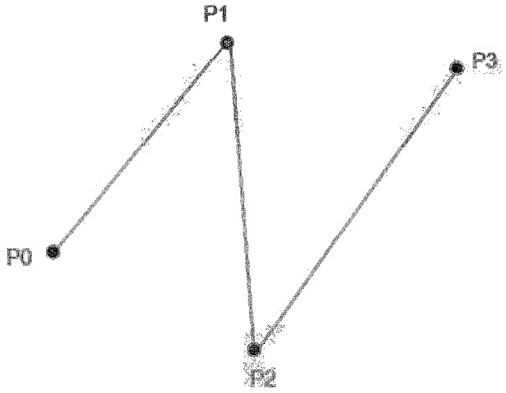
3) Bezier Curves (8 Points)

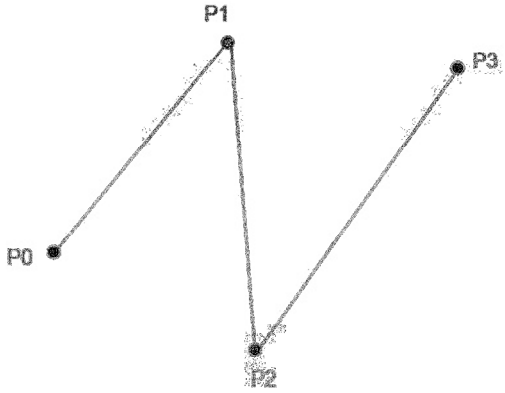
Given are the four control points of a Bezier Curve: P_0, P_1, P_2 *and* P_3 (see diagrams below). Use the De Casteljau algorithm to approximate point X(t) on the curve for values of: **t = 0.2, t = 0.5 and t = 0.75**

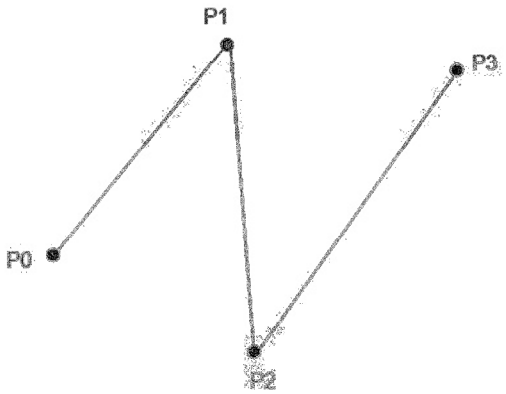
You need to use Linear Interpolation to find the points Q_0, Q_1, Q_2, R_0, R_1 *and X.*

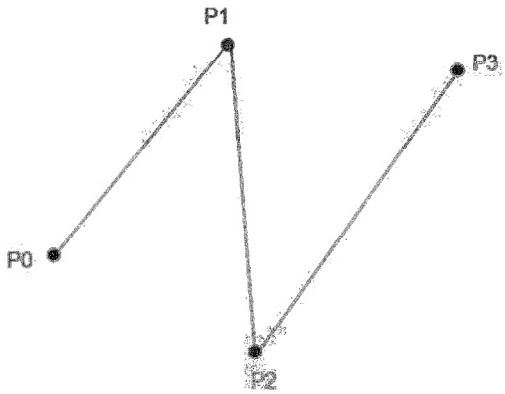
In the first three of the below diagrams, draw the De Casteljau construction of one of the above values of t. (2 points each)

In the fourth diagram, by looking at the points you have obtained, approximate the shape of the curve. (2 points)

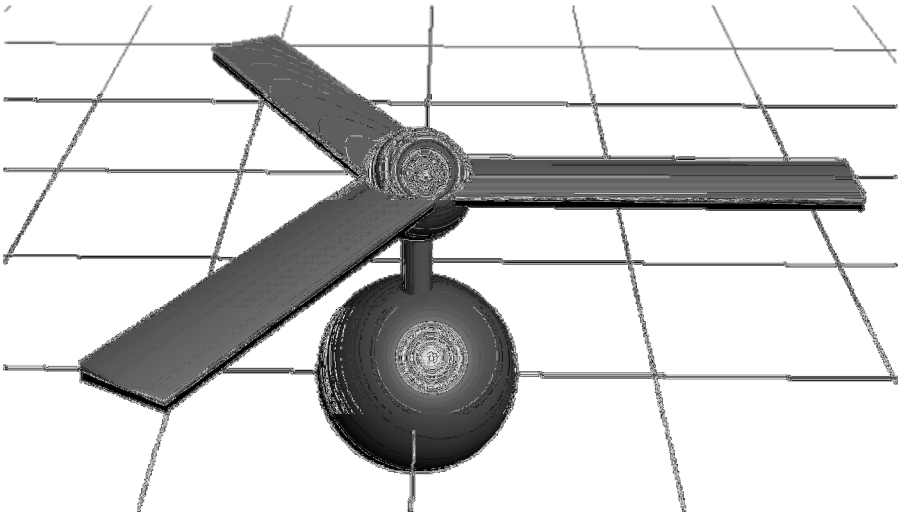








4) Scene Graph (10 Points)



The figure above shows a simple helicopter model. It contains a body, a vertical axis, a top sphere (to hold the main propeller) and three rotor blades.

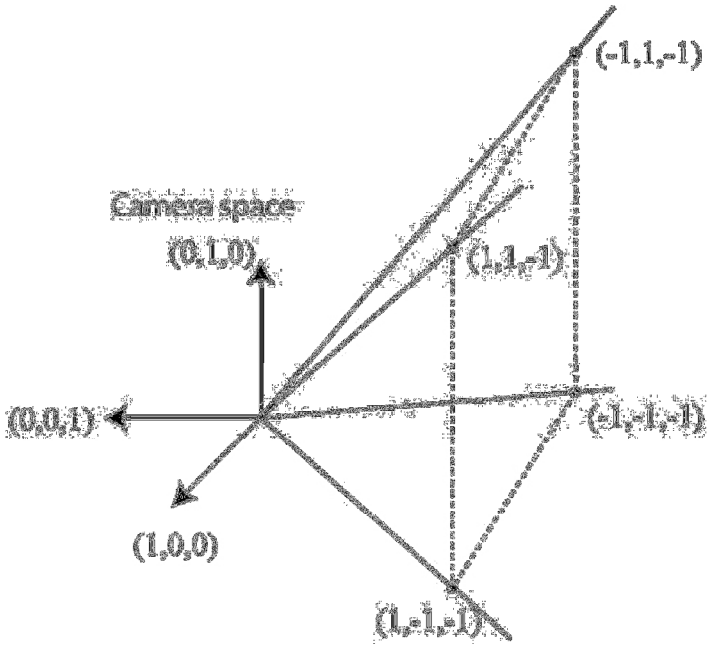
a) Create a scene graph for the model and draw it below.

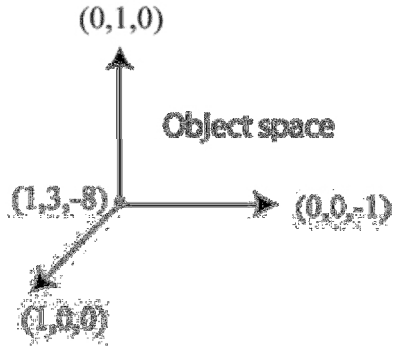
b) How would you use the scene graph to animate the vertical ascent (take-off) of the helicopter? As the helicopter lifts, the three rotor blades should rotate around the vertical axis. Indicate which nodes of the scene graph need to be modified and how.

5) 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.





6) Environment Mapping (10 Points)

a) Which problem does Environment Mapping attempt to solve? (2 points)

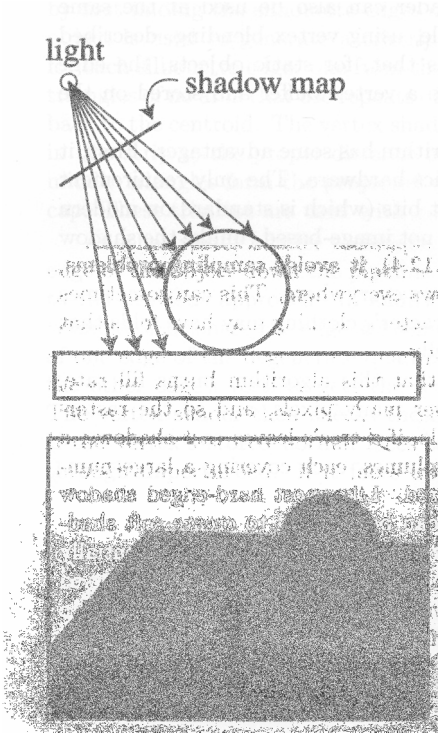
b) Which two types of geometries for environment maps did we discuss in class? Name one advantage for each of them that it has over the other. (4 points)

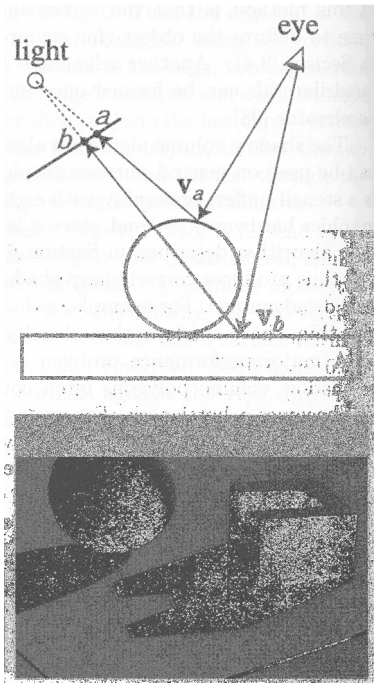
c) With environment mapping, is it easier to render metallic or diffuse objects? Explain why. (2 points)

d) Name two particularly computationally expensive operations which are part of the environment mapping algorithm, which can be done efficiently in a shader. (2 points)

7) Shadow Mapping (10 Points)

Using the images below, describe the two steps of the Shadow Mapping algorithm.





8) 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 toon shading use to give images a cartoon-style look? (2 points)

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