6.837 Introduction to Computer Graphics
Quiz 2

Thursday November 20, 2003 2:40-4pm
One hand-written sheet of notes allowed

Name:

1	/ 4
2	/ 15
3	/ 5
4	/ 5
5	/ 12
6	/ 2
7	/ 7
Total	/ 50

1 Animation [/4]

1.1 Quaternions vs. Euler Angles [/2]

Quaternions are generally used for animation instead of Euler Angles. Why? Give 2 reasons.

1.2 Interpolation in Quaternion Space [/2]

If we linearly interpolate the values of two rotations in quaternion space, the speed of animation will not be constant. How does the speed vary? Draw a simple figure to explain this variation.

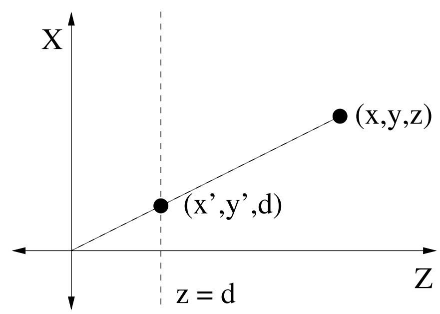
2 Rendering pipeline [/15]

2.1 Ray Casting vs. the Graphics Pipeline [/2]

Describe the main algorithmic difference between standard ray casting and rendering using the graphics pipeline.

2.2 Perspective Projection [/4]

Give the 4x4 matrix corresponding to a perspective projection of all points to the z=d plane with the eyepoint at the origin.
Hint: Use similar triangles.



$$\underset{\substack{\Uparrow \\ \text{matrix}}}{\begin{bmatrix} & & & \\ & & & \\ & & & \\ & & & \end{bmatrix}}\begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \underset{\substack{\Uparrow \\ \text{un-homogenized} \\ \text{point}}}{\begin{bmatrix} \quad \\ \quad \\ \quad \\ \quad \end{bmatrix}} \overset{\textit{homogenize}}{\Longrightarrow} \underset{\substack{\Uparrow \\ \text{homogenized} \\ \text{point}}}{\begin{bmatrix} \quad \\ \quad \\ \quad \\ \quad \end{bmatrix}} = \begin{bmatrix} x' \\ y' \\ d \\ 1 \end{bmatrix}$$

2.3 Triangle Rasterization [/5]

Describe how to rasterize a triangle with vertices $v0$, $v1$, and $v2$ into the framebuffer, as implemented on a modern graphics card. Use pseudo-code as appropriate. Make sure that small triangles are processed efficiently. Be specific about how you determine that a point is inside the triangle.

2.4 The z-buffer [/2]

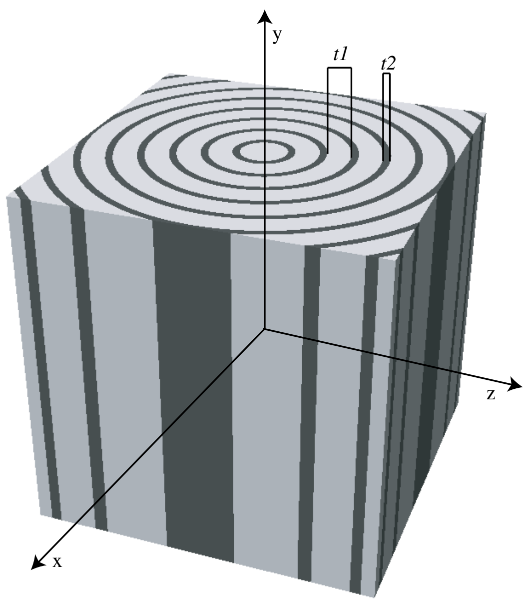
How do you modify your answer to the previous question to use the z-buffer to correctly rasterize multiple overlapping triangles?

2.5 Linearity of Projection [/2]

Can we interpolate z linearly in screen space? Explain.

3 Procedural Solid Texturing [/5]

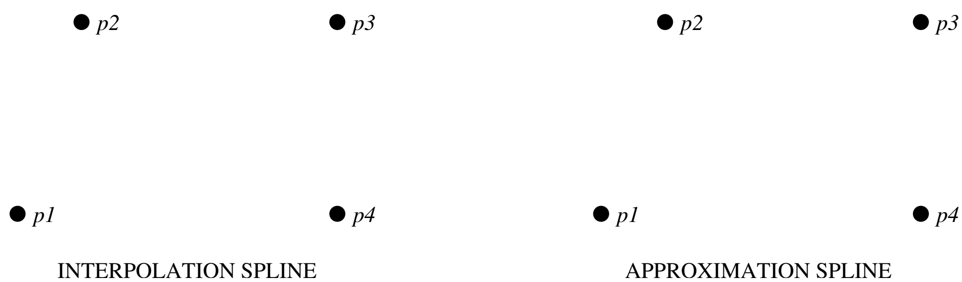
Write pseudo-code for a procedural wood shader similar to that shown in the image below. The wood material is composed of two other materials, *m1* and *m2*, arranged in cylindrical bands around the y-axis with thicknesses *t1* and *t2*. Given point p, return the appropriate material. Don't worry about the variations in circular cross-section or band thickness seen in natural wood grain.



4 Curves and surfaces [/5]

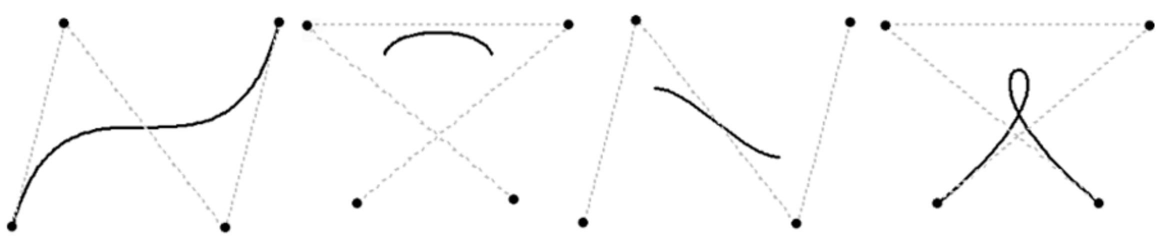
4.1 Interpolation vs. Approximation Splines [/1]

Sketch an interpolation and an approximation spline curve for the 4 control points below.



4.2 Bezier vs. B-Spline [/1]

Label each curve below as Bezier or B-spline.



4.3 Polynomial Degree [/1]

If we want a single polynomial to pass through n points, what degree polynomial is required?

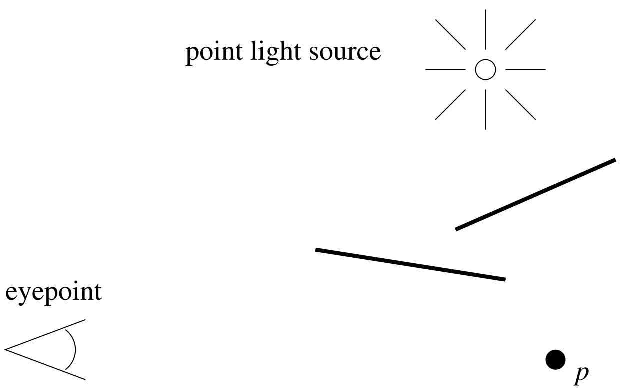
4.4 Modeling with high order polynomials [/2]

Why can it be difficult to model with high-order interpolation polynomials?

5 Shadows [/12]

5.1 Shadow Volumes [/3]

Sketch the shadow volumes corresponding to this 2D scene and explain how the technique is used to determine whether point p is in shadow.



5.2 Shadow Techniques [/5]

For each shadow algorithm below, check the boxes to indicate the features and limitations inherent in the technique. The features and limitations may be used more than once.

Features / Limitations	Planar Fake Shadows	Projective Texture Shadows	Shadow Maps	Shadow Volumes	Ray Casting Shadows
Allows objects to cast shadows on themselves (self shadowing)					
Permits shadows on arbitrary surfaces (i.e. curved)					
Renders geometry from the viewpoint of the light					
Generates extra geometric primitives					
Limited resolution of intermediate representation can result in jaggie shadow artifacts					

5.3 Soft Shadows [/2]

Describe how one of these shadowing techniques can be extended to produce soft shadows from an area light source.

5.4 The Bias (Epsilon) Problem [/2]

Describe for one of these shadowing techniques how and why it suffers from the bias (epsilon) problem.

6 Color [/2]

6.1 Metamers [/2]

What are metamers?

7 Global Illumination [/7]

7.1 Radiosity [/1]

What photorealistic effects are missing from your ray tracer that can be captured using radiosity?

7.2 Radiosity [/1]

What other aspect of the radiosity computation makes it a popular choice for interactive architectural visualization and games?

7.3 Monte-Carlo Ray Tracing [/2]

What additional effects are captured by extending a basic ray tracing algorithm with Monte-Carlo ray tracing techniques?

7.4 Form Factors for Radiosity [/3]

Order these pairs of patches by the form factor F_{ij} (the fraction of light energy leaving patch j that arrives at patch i). Label the pair with the largest form factor '**1**', the 2nd largest '**2**', etc.