CPSC 314 **Final Exam** **2012 April 23**

Name: ______________________ **Student ID:** ______________________

You have 2.5 hours to complete the exam. Write your answers in the spaces provided.

1) Show how to compute the barycentric coordinates α, β, γ of a point (x, y) with respect to a triangle with corners (x_0, y_0), (x_1, y_1), and (x_2, y_2).

2) If a triangle rasterizer only shades fragments of triangles with barycentric coordinates $\alpha > 0$, $\beta > 0$, and $\gamma > 0$, what problem might happen?

3) For a scene with high depth complexity, why can raytracing be faster than straightforward Z-buffer rasterization?

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4) Sketch a collection of triangles which could not be correctly drawn with the Painter's Algorithm, and instead need Z-buffer or another more advanced algorithm for hidden surface elimination. Explain the problem.

5) Given data points $f(3) = 10$ and $f(7) = 30$, lerp between them to estimate $f(4)$.

6) Figure out a view transform (that maps from world space to camera space) for a camera at world space position $(3, -4, 5)$ looking at $(0, -4, 5)$. Express your answer as a **product of** 4×4 **matrices**.

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7) Explain an advantage of using matrices to represent affine transforms and perspective projections, from the software development standpoint.

8) What problem would this perspective projection matrix cause for a renderer?

$$\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & -1 & 0 \end{pmatrix}$$

9) Given a 4×4 transformation matrix A mapping from one coordinate system to another, how do you transform a point (x, y, z), a direction vector (u, v, w), and a normal vector (p, q, r)?

10) What is frustum culling and how does it help speed up rasterization?

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11) Write pseudocode for a matte shader for a rasterizer (as in assignment 2), ignoring shadows. Assume you can query light shaders for lighting information such as the direction to and the intensity of the light at the point being shaded.

12) Write non-recursive pseudocode for efficiently finding the first ray intersection with a scene stored in a BVH.

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13) Explain a shading effect which is relatively easy for a raytracer (like your assignment 3) but very hard or impossible for rasterization (like your assignment 2).

14) Give pseudocode for checking if a ray intersects a double cone implicitly defined by $y^2 = x^2 + z^2$.

15) Suppose a shader looked up a texture image T of size $n \times n$ at texture coordinates (u, v) with a simple array read $T(\lfloor n\, u \rfloor, \lfloor n\, v \rfloor)$. What visual artifact could happen in magnification? What visual artifact could happen in minification?

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16) Explain how mipmaps solve the issue of minification.

17) What is dithering, and why does it produce perceptually better results than round-to-nearest quantization?

18) Why is it impossible to accurately reproduce the colours in a rainbow by taking a photograph and displaying it on a monitor? Discuss both the camera and the computer display.

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19) What are metamers, and why are they so important for computer displays?

20) A simple *displacement shader* changes the location of the point $\vec{x}$ being shaded to $\vec{x} + d(u, v)\hat{n}$ where (u, v) are the texture coordinates, $d()$ is the displacement function, and $\hat{n}$ is the original normal. What is the new normal of the displaced point? Assume you have access to any partial derivatives you might need.