Name: ______________________ **Student ID:** ______________________

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

No aids (books, notes, calculators, mobile phones, PDA's, music players, death rays, other electronic devices, etc.) are permitted.

1) Write down a parametric (explicit) description of the line (in 3D) that passes through two distinct points $\vec{x}_0 = (x_0, y_0, z_0)$ and $\vec{x}_1 = (x_1, y_1, z_1)$.

2) Why did we use ≤ 0 and ≥ 0 instead of < 0 and > 0 in the tests for triangle rasterization?

3) Demonstrate that the sum of the edge functions we used for rasterization is constant (independent of the point being tested).

4) Write down the formula for Gouraud interpolation of colour in a triangle, and the formula for Phong normal interpolation, using barycentric coordinates

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5) Explain how matrix multiplication is used to express translation of 3D points.

6) How is a given 4×4 transformation matrix M used to transform a ray in 3D?

7) Of the two perspective projection matrices A and B below, why is B more useful?

$$A = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & -1 & 0 \end{pmatrix} \qquad B = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & -1 \\ 0 & 0 & -1 & 0 \end{pmatrix}$$

8) Why is "instancing" a useful feature of hierarchical modeling?

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9) How do you clip a line segment (like the edge of a triangle) against the near clipping plane in camera space?

10) Describe a scene where ray-casting would be much more efficient than Z-buffer hidden surface removal, and explain why it could be faster.

11) What is the camera-space ray corresponding to pixel (i, j) in an $m \times n$ image for an **orthographic** projection with near clipping plane at $z = -n$ and the usual l, r, b, t parameters to describe the left, right, bottom and top camera space x and y coordinates on the near clipping plane.

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12) How do you intersect a ray with a sphere?

13) Write down pseudo-code for intersecting a ray with a large collection of objects with a BVH; you don't need to write out the details of intersecting with an individual bounding box.

14) Upon which of the following does Lambertian shading depend: the direction to the light $\vec{l}$, the reflection direction $\vec{r}$, the normal $\hat{n}$, the viewing direction $\vec{d}$?

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15) What is ambient light supposed to model?

16) How do raytracers handle shadows?

17) Give both an advantage and a problem with Gouraud shading applied to a model with the glossy Phong material model.

18) Give a formula for the surface normal of the ellipsoid described implicitly by $3x^2+y^2+5z^2-10=0$.

19) Give both an advantage and a disadvantage to using a procedural texture instead of a voxel array for 3D textures.

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20) How does OpenGL deal with the magnification and minification problems?

21) What's the simplest way to mitigate quantization artifacts?

22) Write down how to test if a sphere in 3D overlaps an axis-aligned bounding box.

23) How might you implement displacement mapping in a ray-tracer?

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24) List three different colour spaces.

25) What are metamers, why do they exist, and why are they crucial for computer displays?

26) Why can't you mix red, green and blue light to produce every colour possible?