EXAM IN

COMPUTER GRAPHICS

TSBK05/TSEA55

Time:	12th of August, 2004, 8-12
Room:	Garnisonen
Teacher:	Ingemar Ragnemalm, visits around 10
Allowed help:	None
Requirement to pass:	Grade 3: 21 points Grade 4: 31 points Grade 5: 41 points C program: G: 21 points. VG: 36 points. or numbers as above ECTS: E: 21 points D: 26 points C: 31 points B: 36 points A: 41 points

Answers may be given in swedish or english.

Good luck!

1. OpenGL programming

a) Transparent objects, objects rendered with an alpha value like 0.5, may cause problems in OpenGL. Describe how a scene can be incorrectly rendered when , and suggest a remedy.

b) Explain the purpose of the call glMatrixMode, with its two arguments GL_MODELVIEW and GL_PROJECTION.

(4p)

2. Transformations

a) In 3D space, an axis is given by the points (2, 1, 4) and (3, 1, 2). Give a sequence of 4x4 matrixes, each defining one basic geometric transformation (translations, rotation around origin, scaling and skewing), that define a transformation that performs rotation around the given axis by an angle α. Derive the contents of each matrix as numeric values or appropriate, clearly defined symbols. Write the total operation as a sequence of matrix multiplications. You don't have to multiply the matrices together.

b) All the typical 3D operations that we use can easily be performed without matrices, or by using smaller matrices than 4x4. Motivate why we use matrices for simple operations like translation, scaling and mirroring.

c) How do you, in the simplest possible way, inverse transformation matrices for 1) rotation, 2) translation, 3) scaling and 4) shearing?

(7p)

3. Curve generation

a) A curve is given by the formula $y = x^2 - ax$, where a is an integer, $a > 0$. Derive the incremental updating of the decision variable in the midpoint algorithm to plot this curve, 8-connected, starting at (0,0) and continuing in positive x direction. Also, calculate the starting value for the decision parameter.

b) In order to draw any part of the curve in a), you must use different expressions for different parts of the curve. At what points must the algorithm switch expressions, and why? Illustrate this in a figure. (You don't have to derive the incremental updating expressions for the other parts.)

c) How can you reduce computation time of the polynomial $ax^3 + bx^2 + cx + d$ by using Horner's Rule?

(8p)

4. Miscellaneous

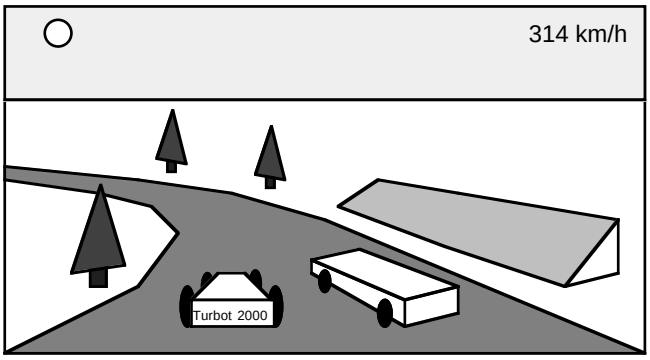
a) When doing Scan-Line Polygon Fill, why can there be a problem when the scanline being processed intersects a vertex? How can this be resolved?

b) Given a point **p** and a plane given by a point **q** and a normal vector **n**, how do you test on what side of the plane the point is located?

(4p)

5. Mapping techniques

a) Linus and Linnea have created a particularly pleasing project, a car racing game, illustrated by the figure below. The scene includes the cars, the racing track, trees, sky, grass, etc. All surfaces are texture mapped.



They were over-ambitious enough to implement the low-level renderer themselves. Unfortunately, they have performance problems, and have found that the problem is that the texture mapping is too slow. They need to render the textured surfaces in not more than half the time. Since they have used the highest possible precision, they know that this can be improved by using less precise algorithms. However, they do not want to sacrifice more visual quality than necessary. Removing texture mapping for any surface is not an option, neither is lower resolution or lower polygon count.

Suggest a remedy that would compromise rendering speed and rendering quality for this application. Hint: Different parts of the scene can be handled in different ways. Describe what parts should be rendered one way or the other.

b) What is a billboard? Give an example of when a billboard or billboard-like object (impostor) is useful.

(5p)

6. Collision detection

a) What is the difference between AABB and OBB? Compare both how they are defined and advantages and disadvantages in practical use for collision detection.

b) Describe, using figures, the tests needed in the narrow phase, for testing whether two polyhedra intersect or not.

c) Consider two small spherical objects of the same size and weight colliding with each other. The collision is elastic. Given arbitrary initial speed vectors v_1 and v_2 and the point of impact p, express the speed vectors after the collision.

(7p)

7. Light, shading and ray-tracing

a) A student tries to explain how ray-tracing works, and writes:

A ray starts at the light source, and is traced until it intersects a surface. In the surface, the ray may be reflected or refracted, creating new rays that are traced recursively. The rays are traced until they reach the camera or until they reach the maximum search depth.

Something is wrong in this explanation. Correct the errors. (Language errors are ignored.)

b) The popular three-component illumination model can be described by the following formula:

$$I = k_a I_a + k_d I_l(\mathbf{N} \cdot \mathbf{L}) + k_s I_l(\mathbf{V} \cdot \mathbf{R})^n$$

Explain what each symbol represents, using text and figure(s) as appropriate.

c) A scene is all black except for two surfaces, numbered 1 and 2. Number 1 is a large white lamp. Number 2 is a smaller light grey object.

Surface 1 is a light source with intensity = 1. It also reflects light as a 100% white surface (reflecting all incoming light). Surface 2 is light grey, reflecting 75% of all incoming light.

Since surface 2 is so small, only one third of the total light emitted from surface 1 hits surface 2. Surface 1, however, is larger, so 2/3 of the light emitted from surface 2 hits surface 1.

The radiosity equation is:

$$B_k = E_k + \rho_k \sum_{j=1}^{n} B_j F_{jk}$$

Express the light exchange between the two surfaces above using the radiosity equation. How much light does surface 2 emit?

(8p)

8. Visible surface detection

a) When Painter's algorithm (non-BSP version) sorts polygons, how does it tell which one out of two polygons that is the closest and the farthest one?

b) Show, from a computation time point of view, using the plane equation and other geometrical formulas, that the depth buffer (Z buffer) should hold values proportional to z^{-1} rather than z.

c) Outline the principle for portals, using a figure. For what kind of environments is this suitable?

(7p)