EXAM IN

COMPUTER GRAPHICS

TSEA55

Time:	21th of August, 2002, 8-12
Room:	Garnisonen
Teacher:	Ingemar Ragnemalm, visits the room around 10
Allowed help:	None
Requirement to pass:	21 points Grade 4: 31 points Grade 5: 41 points

Good luck!

1. OpenGL programming

a) What shape is drawn by the following code, and where? Draw a figure, and show clearly where the origin is located.

```
glLoadIdentity();
glRotatef(180, 1,0,0);
glTranslatef(0, 1, 0);
glRotatef(45, 0,0,1);
glBegin(GL_POLYGON);
glVertex2f(0, 0);
glVertex2f(1, 0);
glVertex2f(0, 0.5);
glEnd();
```

b) In the example above, glLoadIdentity is used. In typical OpenGL code, glLoadIdentity is not likely to appear at the beginning of the redrawing routine (i.e. the display() function). Why? What is used instead?

(4p)

2. Transformations

a) In 3D space, an axis is given by the points (2, 4, 3) and (4, 4, 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 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) Under what condition is it possible to invert a matrix simply by transposing it? For what typical geometric transformations does that apply?

(7p)

3. Curve generation

a) Derive the incremental updating of the decision variable in the midpoint algorithm to plot a **4-connected circle** of a given radius. The radius is always integer. Also, calculate the starting value for the decision parameter.

b) Unless you take advantage of mirroring (which, of course, you should), you must use different expressions for different parts of the curve in a). At what points must the algorithm switch expressions, and why? (You don't have to derive the incremental updating expressions for the other parts.)

(7p)

4. Light, shading and ray-tracing

a) Anti-aliasing in raytracing is often implemented by supersampling. This can be done by rays in regular patterns or by random rays. Why can random rays give a better result than regular patterns?

b) Describe the Phong reflection model. (If you can not give the formulas, describe with figures.)

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 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 grey, reflecting 50% of all incoming light.

Since surface 2 is so small, only one quarter of the total light emitted from surface 1 hits surface 2. Surface 1, however, is larger, so one half 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)

5. Miscellaneous

a) Given the camera position **p**, the forward vector **n**, and the up vector **v** (where **v** is guaranteed to be orthogonal to **n**), how do you build a matrix that can be used for the world-to-camera transformation?

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)

6. Collision detection

DENNA UPPGIFT BLEV MYCKET FÖR LÄTT. ÄVEN MED “vector” NEDAN ÄR DET BILLIGA POÄNG

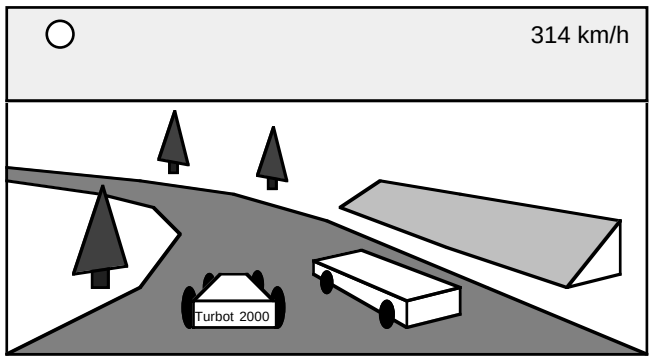
a) Consider a small object (i.e. the camera) that collides with a large, heavy object (i.e. a planet). The collision is elastic. Given an arbitrary initial speed vector v, what speed *vector* should the smaller object have after the collision?

b) When doing camera-polygon collision handling, the camera is often treated as a sphere. The size of the sphere should match another parameter in the 3D system. Which one?

(6p)

7. 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.

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 errors are avoided by using mip mapping? Why are these errors not totally eliminated by mip mapping only?

c) Outline the principles for environment mapping.

(7p)

8. Visible surface detection

a) Explain why transparent objects (semi-transparent surfaces or textured surfaces with transparent or semi-transparent texels) cause problems when using Z-buffering, and suggest how the problem is solved.

b) A large 3D world can include thousands of objects and millions of polygons. Suggest and briefly outline two methods for managing such a world.

c) A student is working with the low-level labs and implements backface culling. The student then makes the common mistake to do this by taking the dot product of the camera forward vector by the normal vector of each surface. A cube is drawn but some surfaces are badly classified. Which ones? Exemplify with a figure.

(7p)