EXAM IN

COMPUTER GRAPHICS

TSBK07

(TEN1)

Time:	5th of June, 2015, 8-12
Room:	KÅRA
Teacher:	Ingemar Ragnemalm, visits around 9 and 11
Allowed help:	None

Requirement to pass:
- Grade 3: 21 points
- Grade 4: 31 points
- Grade 5: 41 points

ECTS:
- C: 21 points
- B: 31 points
- A: 41 points

Answers may be given in swedish or english.

Please make a special note if you followed the course before 2012. Some answers may be slightly different depending on that and I need to know what material you studied (old or new) to make fair scoring.

- Wish us luck!
- I wish you skill!
[Martin Landau, "Mission Impossible"]

1. OpenGL programming

a) In a GLSL shader, it is legal to write like this:

```
a = b.st;
```

What does this mean? Explain, and define the concept in more general terms.

(2p)

b) If you ask OpenGL to load a color as GL_RGB, what number of bits per pixel would that imply? Is there some more information that we need to know this?

(1p)

c) In our first OpenGL examples, models were drawn with glDrawArrays(). Motivate why glDrawElements() can be a better choice.

(2p)

d) In GLSL, input variables from the host program may be given as *uniform* or *attribute* (in) variables. What is the difference between these concepts?

(2p)

2. Transformations

a) In a 3D scene, you wish to perform shearing along a specific axis. The axis is not aligned with nor orthogonal to any of the basis axes. Give a sequence of 4x4 matrixes that define a transformation that shears along an axis given by the direction **v** through the point **p**. You don't have to multiply the matrices together. Content of matrices must be given, and derived from the geometry if needed. A solution that omits the derivation or contents of some matrix may still qualify for partial score.

(5p)

b) Specify how you can construct a camera placement (world-to-view matrix) using only rotations and translations, in order to place the camera in (1, 0, 0) looking at origin.

(3p)

3. Light, shading and ray-tracing

a) Describe the difference between Phong and Gouraud shading. Both quality and performance aspects should be included.

(2p)

b) Jittering can be used for many effects where the ray is split into several when a ray hits a surface (such as fuzzy reflections and fuzzy translucency). Give two examples of jittering effects where this is *not* the case.

(2p)

c) Write a formula for the 3-component light model allowing for multiple light sources.

(3p)

d) How are shadows produced in radiosity? Describe enough of the method to clarify how they are created.

(3p)

4. Surface detail

a) Describe MIP mapping. It does not always give a good results; there is a case when even the best settings does not help. What is this case?

(2p)

b) A skybox can sometimes suffer from visible edges between the quads, even if the texture looks perfectly correct. Explain why this happens, and how you can fix the problem.

(2p)

5. Curve generation

a) Describe the difference between C^1 and G^1 continuity.

(2p)

b) Is the Catmull-Rom spline an interpolating or approximating spline? Motivate your answer.

(1p)

c) Prove that a quadratic Bézier (three-point Bézier) can be expressed as an interpolation of interpolations. The final Bézier can be expressed as:

$$\mathbf{p}(u) = (1 - u)^2\mathbf{p}_0 + 2(1-u)u\mathbf{p}_1 + u^2\mathbf{p}_2,\ u \in [0, 1]$$

Illustrating the process in figures (showing that you understand the principle) can give partial score, while full score requires a mathematical solution.

(4p)

6. Miscellaneous

a) A vector **v** should be mirrored over a vector **n**. Both vectors are normalized. Derive the formula for calculating the mirrored vector.

(2p)

b) A self-squaring fractal works with a certain radius parameter. What happens if the algorithm starts outside this radius?

(2p)

7. Collision detection and animation

a) You want to perform collision detection with an elongated shape, a plank. What kind of bounding shape (for the broad phase) would you use? Why?

(2p)

b) Suggest a method to accelerate collision detection in a scene with many moving objects. A figure is recommended.

(2p)

8. Visible surface detection and large worlds

a) A student describes frustum culling like this:

The frustum is set up as six planes. In order to optimize it, the top and bottom plane are removed. This is tested against spherical bounding shapes of objects in the scene. The spheres are transformed to view coordinates where the tests against the frustum are performed. This is done for each sphere and plane by using a point **a** in the frustum plane, the plane's normalized normal vector **n** pointing outwards, the sphere position **c** and its radius r. Then, the object is drawn if

$$\mathbf{a} \bullet \mathbf{n} > (\mathbf{c} + \mathbf{n} \cdot r)$$

is true for any plane.

The examiner is not satisfied with this answer. Why? Correct the errors and/or bad reasoning.

(4p)

b) Describe the cells and portals method with a figure. For what kind of environment is this suitable?

(2p)