EXAM IN

COMPUTER GRAPHICS

TSBK07

(TEN1)

Time: 5th of June, 2019, 14-18

Room: TERE, T1, T2

Teacher: Ingemar Ragnemalm, visits around 15 and 17.

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.

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

1. OpenGL programming

a) What is a shader? Describe the concept, the two most common shader types. What output do they produce and what happens with it?

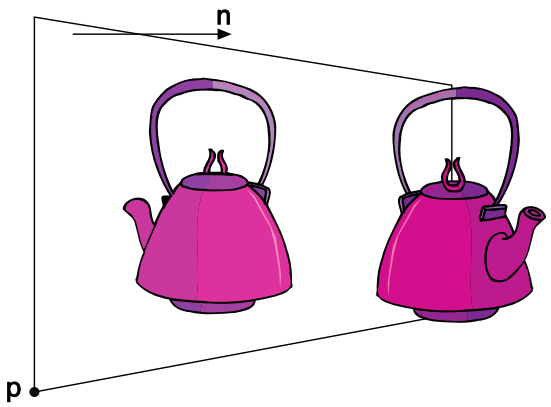
(3p)

b) What is the difference between a VBO (vertex buffer object) and a VAO (vertex array object)? What do they refer to?

(2p)

2. Transformations

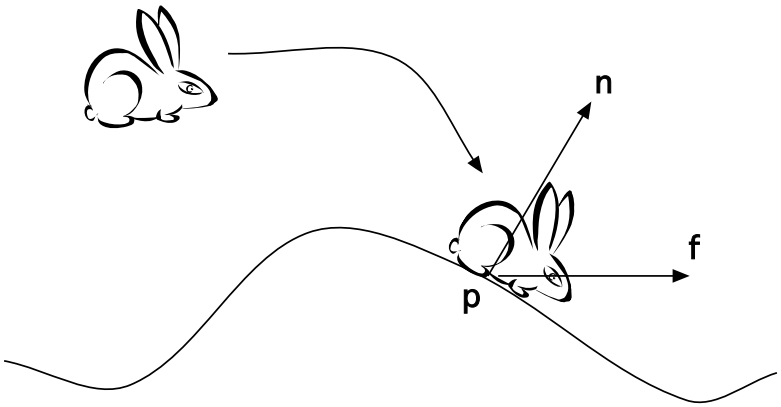
a) A mirror is located in a plane given by the point **p** and the normal vector **n**. The vector **n** is parallel to the xz plane (y component is zero). They are given in world coordinates. Various geometry is located in front of the mirror.



Give a sequence of 4x4 matrices that calculates a version of the scene mirrored over the given plane. You do not have to multiply the matrices together. Consider the mirror infinite; you do not have to mask by the edges of the mirror.

(3p)

b) You have a model, e.g. a bunny, which should slide over a surface, e.g. a terrain, in a 3D scene. It is placed by movement given by a vector **f** i the xz plane, but then the height and orientation should be adjusted to the terrain. You want the bunny to align with the surface as well as always pointing as well as possible in the direction it is travelling. The bunny model is given in model coordinates. You get its desired location as **p**, its movement direction as **f** and the normal vector of the surface as **n**. The vectors are given in world coordinates. The model's forward direction is along negative z.



Give a sequence of 4x4 matrices (translations and rotations) that places the model (model to world) as described above. You do not have to multiply the matrices together.

(4p)

c) For the same scene as (b), also produce a matrix that places the camera at the bunny (1st person view, a world to view matrix) looking along the bunny's actual forward direction as produced in (b).

(2p)

3. Light, shading and ray-tracing

a) Write a formula for the three-component light model. You want to adjust the specularity of an object. Which values in the formula do you suggest to do that with?

(3p)

b) How are shadows produced in ray-tracing?

(1p)

c) Give three examples of effects produced by distributed ray-tracing. Use a figure to clarify.

(2p)

4. Surface detail

a) Describe how anti-aliasing *of textures* is performed, as a separate method different from anti-aliasing of the entire scene. There are some different settings for it, which ones?

(3p)

b) A skybox is a way to put an environment over a scene. How is it rendered differently than other parts of a scene?

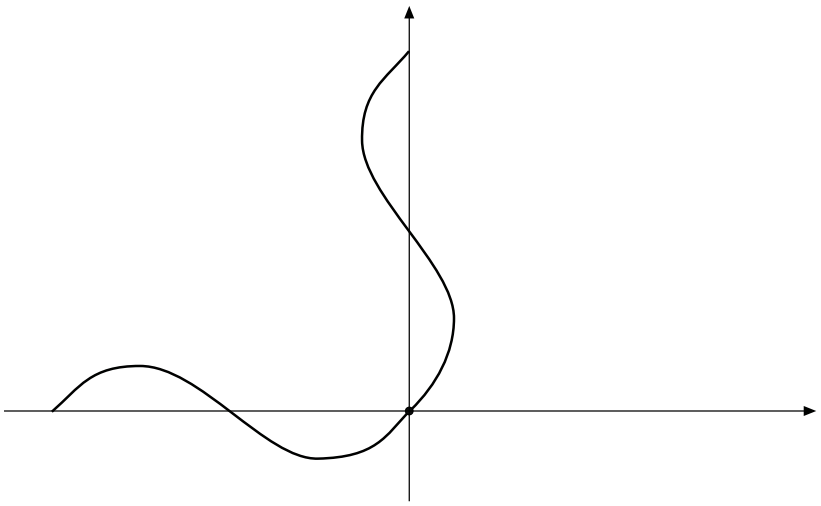
(3p)

c) A texture is referenced in two different ways, by a *texture object* and by a *texture unit*. Explain the difference and usage of the two.

(2p)

5. Curve generation

a) Someone (who didn't know of the better choices) has chosen to model a curve using sections of harmonic functions, sin and cos. In the figure, you see two sections, one along x and one along y. The two sections are defined as $y = \sin x$ and the other as $x = \sin y$.



Analyze the continuity for the point where these two sections meet (black dot in the figure) in terms of C^0, C^1... and G^0, G^1.....

(3p)

b) Prove that the Bézier curve will always be within the convex hull of its control points. The proof may be graphical if motivated by a valid argument.

(2p)

c) Is a Catmull-Rom spline approximating or interpolating?

(1p)

6. Miscellaneous

a) Motivate, using reasoning in the frequency plane, why supersampling can give a very good result.

(2p)

b) Flood fill can be performed by trivial recursion. Describe a better method and argue why it is better.

(2p)

7. Collision detection and animation

a) SAT is a common theorem to base collision detection on. Describe how a collision detection can be performed using SAT in a 2D case.

(3p)

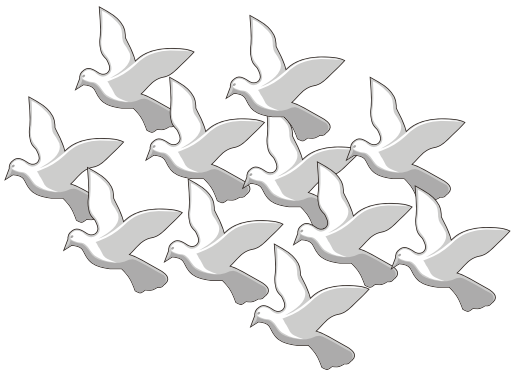
b) For the case when the collision beween two objects has been detected, suggest how to resolve the collision. No rotations need to be involved. You may assume that the objects have the same weight. How can you handle various degrees of elasticity/plasticity?

(3p)

8. Visible surface detection and large worlds

You want to render a scene with a huge number of birds (several millions) spread out over a large area. You use a nice 3D model of a bird. However, your animation is not fast enough. Suggest three methods to accelerate the animation. (Faster or multiple GPUs does not count as a method, neither does ordinary code optimization.)

Each method should be clearly described, possibly with figures, pseudo code and/or appropriate formulas.



You get 1 point for each relevant method and 1 more for describing it sufficiently including *how* it is performed.

(6p)