EXAM IN

COMPUTER GRAPHICS

TSBK07

(TEN1)

Time:	21st of August, 2014, 8-12
Room:	TER1
Teacher:	Ingemar Ragnemalm, visits around 10
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) Outline the entire graphics transformation chain described as a sequence of transformations. (You do not need to write matrix contents.) Consider how this is used when making an animation. Describe in what situation each step needs changing, for what purpose.

(3p)

b) Your host program can pass data to the vertex shader stage. This is done in two significantly different ways. Which two, and what is the difference between them?

(2p)

c) In order to produce a normal matrix, a transformation matrix for normals, we can take the inverse transpose of... which matrix?

(1p)

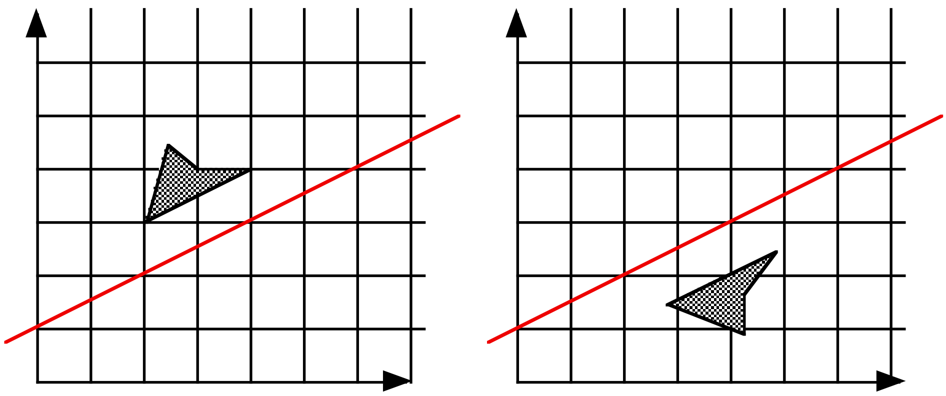
2. Transformations

a) We are using homogenous coordinates for transformations. Write a clear definition/description of how homogenous coordinates work. What common operations require homogenous coordinates?

(3p)

b) In the figure, a 2D shape is shown together with a line (red in the figure). Produce a sequence of 3x3 matrixes that define a transformation that mirrors the shape (or anything else) over a given line. The contents of each matrix should be given and variables should relate to the figure when appropriate. You don't have to multiply the matrices together.

Please ignore any limitation of precision in the drawing. The shape is intended to be mirrored over the line, exactly.

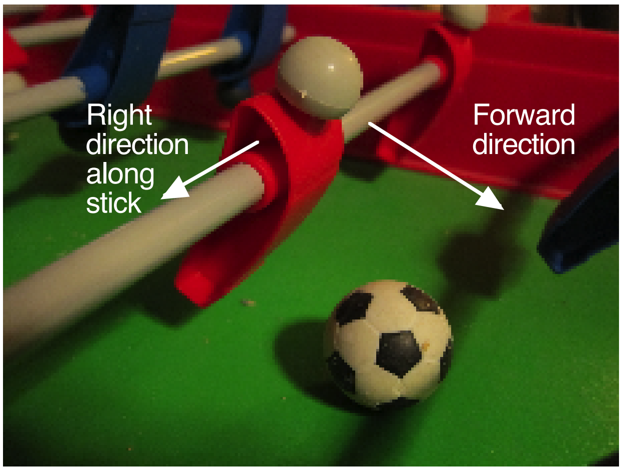


Original shape and position, and the line (red) that the shape is mirrored over

After transformation

(3p)

c) You are writing a simulator for the classic football games with player dolls on twistable sticks. (See photos.) You want a first-person view camera for these player dolls, so you can see the game ”from within” at any time. (The game certainly isn't playable with such a view, this view is simply an extra effect.)

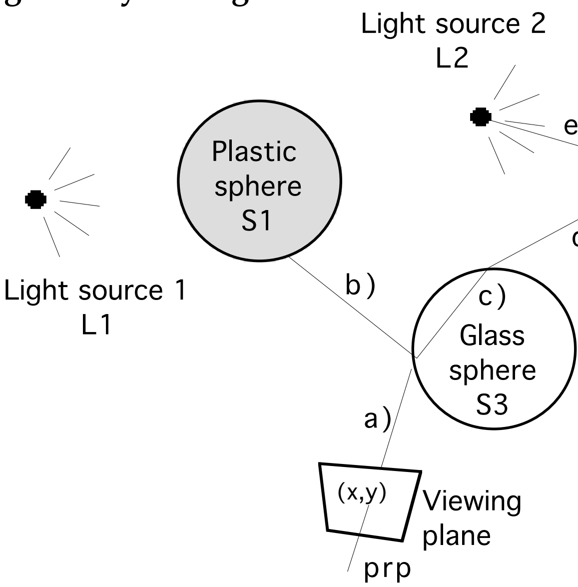


Football game *Football player's coordinates*

The game is always aligned with the X and Z axes, so the side vector of the player is always **u** = (1, 0, 0). The player is positioned in a point **p** and rotated around the X axis by an angle ϕ. (The doll head has an offset from the axis, but you can ignore that and place the camera on the axis, in its chest.) Produce a camera matrix that will produce a first person view for such a doll.

(4p)

3. Light, shading and ray-tracing



a) Write a formula for the three-component light model, using a figure to clarify symbols. The formula should include handling of surfaces facing away from the light source.

(3p)

b) A couple of rays (a-e) used to calculate the pixel (x, y) are shown in the figure. Give each ray appropriate descriptive names. How is each ray formed? Are some rays clearly missing? If so, which ones?

(3p)

4. Surface detail

a) Cylindrical coordinates (θ, v) can be defined by

$$x = R\cos\theta$$
$$y = R\sin\theta$$
$$z = v$$

Write formulas for cylindrical texture mapping, mapping x, y, z to texture coordinates (s, t), normalized to the interval [0, 1].

Only single-argument mathematical functions like $\tan^{-1}$ may be used.

(3p)

b) Describe how mip-mapping works. When accessing a mipmap, what kind of filtering can be performed? Clearly state (or illustrate by a figure) what information this filtering involves.

(2p)

5. Curve generation

a) Is a Bézier curve an interpolating spline or an approximating spline? Why?

(2p)

b) Two segments of a 2D spline is given by the following functions:

$p_x(u) = -3 + 6u - 2u^2$
$p_y(u) = u + u^2$
$q_x(v) = 1 + 4v + 2v^2$
$q_y(v) = 2 + 6v - 2v^3$

What continuity criteria do these segments fulfill for u=1, v=0?

(3p)

6. Miscellaneous

a) Anti-aliasing can be performed by supersampling. Explain why supersampling reduces aliasing, and what behavior you must assume for the signal (the image). The explanation should involve arguments in frequency space.

(3p)

b) Using a figure, illustrate the difference between the odd-even rule and the non-zero winding number rule. The figure should have at least one area where the two rules give different result.

(2p)

7. Collision detection and animation

a) The Separating Axis Theorem is a common base for collision detection, especially in 2D. What does the theorem say? (You don't have to state the theorem exactly.) Why is that not immediately applicable on collision detection, and what more decisions have to be done to make a collision detection algorithm out of it?

(4p)

b) Suggest two bounding shapes suitable for broad phase collision tests of *elongated shapes*.

(2p)

8. Visible surface detection and large worlds

a) A sphere is defined by its center **c** and radius r. A plane (e.g. a side of a viewing frustum) is defined by its normal vector **n** and a point **a** in the plane. Describe a test which tells us whether any part of the sphere is located on the "negative" side of the plane (the side that **n** points away from).

(3p)

b) Is back-face culling an exact, approximative or conservative VSD algorithm? Motivate your answer.

(2p)

c) Describe how a view plane oriented billboard can be implemented.

(2p)