

EXAM IN
COMPUTER GRAPHICS
TSBK05

Time: 11th of March, 2006, 14-18

Room: TER

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

C program: Usually numbers as above, but if you like, we can use the following scale:

G: 21 points.

VG: 36 points.

ECTS:

E: 21 points

D: 26 points

C: 31 points

B: 36 points

A: 41 points

Answers may be given in swedish or english.

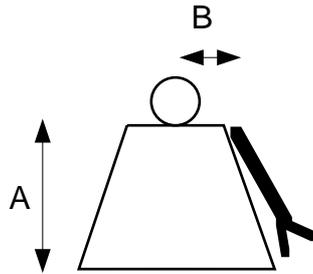
Note: Students who have followed TSEA55 are welcome, but should clearly state that the result should be registered for TSEA55 instead of TSBK05.

Good luck!

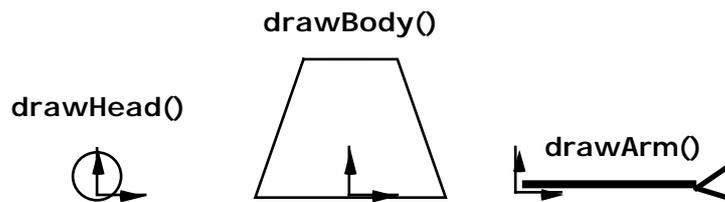
1. OpenGL programming

a) Instead of using functions like `gluLookAt()` for camera placement, you can use `glTranslate` and `glRotate`. Write code for camera placement, including specification of matrix mode, that places the camera in $(1, 0, 0)$, looking along the positive x axis.

b) A robot model with one arm and a rotating head is modelled centered around origin. With the calls `drawBody()`, `drawArm()` and `drawHead()` you can draw its parts. See figures below.



Robot with arm and head



Robot parts, given as function calls, with origin.

Write a function `drawRobot($t_x, t_y, t_z, a_1, a_2, a_3$)` that uses OpenGL code for placing the body, arm and head in the world, and rotating the arm around the x axis (model coordinates) and the head around the y axis. All arguments are scalar floating-point values (i.e. `GLfloat`). The robot position and rotation are given by t_x, t_y, t_z, a_1 . The arm rotation is given as a_2 , and the head rotation as a_3 .

The head joint is placed directly above the body's origin, on the distance A. The arm is placed at height A and with a sideways offset of B.

You should not write code for the entire program, only for the parts that deals with the drawing of the robot, also assuming that `drawBody()`, `drawHead()` and `drawArm()` are provided.

(4p)

2. Curve generation

a) Derive the incremental updating of the decision variable in the midpoint algorithm for plotting the function $y^2 = x^2 + r^2$. The resulting curve should be, 8-connected, starting at $x = 0$ and continuing in positive x direction. Also, calculate the starting value for the decision parameter.

When you have derived one set of updating formula, what parts of the curve are supported by your result? Is it possible to draw the entire curve with your formula? Motivate your conclusion.

b) Is the Bézier spline approximating or interpolating? Motivate your answer using the following functions:

$$BEZ_{0,3} = (1-u)^3$$

$$BEZ_{1,3} = 3u(1-u)^2$$

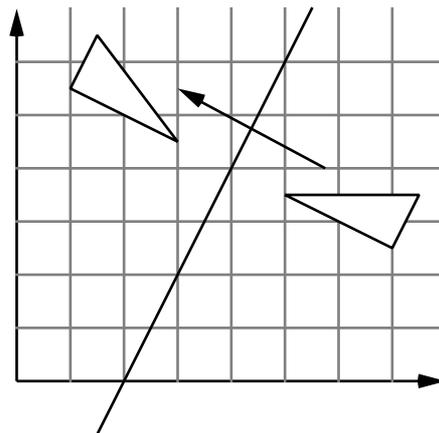
$$BEZ_{2,3} = 3u^2(1-u)$$

$$BEZ_{3,3} = u^3$$

(6p)

3. Transformations

a) In the following figure, a polygon is mirrored over a line. Give that transformation as a sequence of 3x3 matrixes, each defining one basic geometric transformation (translations, rotation around origin, scaling, mirroring). You don't have to multiply the matrices together. Distances and angles may be given as symbols referring to a figure rather than numeric values.



b) If you want to implement your own `gluLookAt()` function, what algebraic operations must it perform? The result should be a transformation matrix. The given data are a camera position \mathbf{p} , a point to look at \mathbf{a} , and an up-vector \mathbf{v} . Note that \mathbf{v} is guaranteed not to be parallel to the forward directions, and with a non-zero length, but that all we know about it.

(6p)

4. Rendering and surface mappings

a) Why is it better for rendering speed if the z buffer contains $1/z$ rather than z ? Prove your claims by appropriate formulas.

b) What is a billboard? Why are billboards and billboard-like objects (impostors) often used in 3D animations?

c)

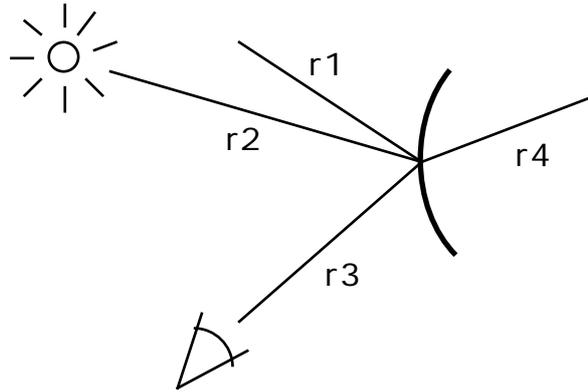
(8p)

5. Light, shading and ray-tracing

The following figure shows four rays involved in a ray-tracing procedure, when a ray hits a transparent surface. Describe the role of each ray. How is each ray calculated?

a) What is r2 used for?

b) How is r1 calculated?



c) Give an example of a situation where the common three-component light model gives a result that is noticeably inferior to the radiosity model.

(4p)

6. Miscellaneous

a)

b)

c) In the Floyd-Steinberg algorithm, a set of parameters are used. In the following figure, five sets of parameters are given together with the neighbor pixel they will affect, with the center pixel marked by *. Some of these sets are unreasonable, useless, in one way or another (but no error occurs in more than one of the cases). Which ones are bad, and why?

1)

	*	5/16
3/16	5/16	3/16

2)

	*	5/8
3/8	5/8	3/8

3)

	4/16	
4/16	*	4/16
	4/16	

4)

*	1
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5)

	*	-7/16
-3/16	-5/16	-1/16

(7p)

7. Collision detection

Collision detection between polyhedra can be split into a broad phase and a narrow phase.

a) What tests are typically carried out in the broad phase? Explain with a figure.

b) The formula $T = N_v C_v + N_p C_p$ describes the load balance between the broad and the narrow phase. Explain this formula.

c) What tests are typically carried out in the narrow phase? Explain with a figure.

(8p)

8. Visible surface detection and scene management

a) Given a subdivision of a scene into cells, explain how you can calculate the potentially visible set (PVS) for a certain cell.

b) Is the method you described in a) an exact, approximate or conservative method? Motivate your answer.

c) Outline how frustum culling can be applied to individual objects. Use a figure to clarify what calculations must be carried out.

(7p)