EXAM IN

COMPUTER GRAPHICS

TSBK05/TSEA55

Time:	20th of April, 2004, 8-12
Room:	U3, U14, U15
Teacher:	Ingemar Ragnemalm, visits around 10
Allowed help:	None
Requirement to pass:	Grade 3: 21 points Grade 4: 31 points Grade 5: 41 points C program: G: 21 points. VG: 36 points. or numbers as above ECTS: E: 21 points D: 26 points C: 31 points B: 36 points A: 41 points

Answers may be given in swedish or english.

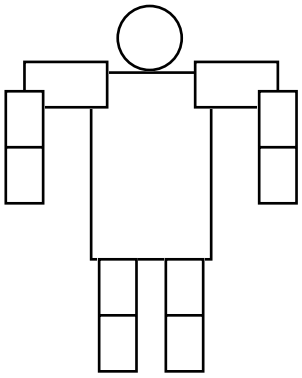
Good luck!

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) Outline how hierarcical modelling is performed with OpenGL. As example, take a robot model like the one below:



How is the movement of the parts of the robot modelled? Use figures and code to clarify your statements. (Hint: This is essentially the same principle as the windmill, but with more joints.)

(5p)

2. Transformations

a) A plane in 3D space is given by the plane equation $2x+3y = 5$. Give a sequence of standard transformations (translation, rotation, scaling, mirroring) given as matrices that performs mirroring over this plane. The contents of each matrix as well as the order of multiplications should be given. You do not have to multiply the matrices together.

b) Which of the following statements about standard transformations are true? (R = rotation, T = translation, S = scaling, M^T = transposed, M^{-1} = inverse)

(1) $R(\alpha)^T = R(-\alpha)$ (2) $T(p)^{-1} = T(-p)^T$ (3) $S(a)^{-1} = S(-a)$

(4) $R(\alpha)^{-1} = R(-\alpha)^T$ (5) $T(p) = T(-p)^{-1}$ (6) $S(a)^{-1} = S(1/a)^T$

(6p)

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.)

c) The following polynomials define two segments of a 2D spline, defined in the interval $0 < u < 1$ and $1 < u < 2$, respectively. Which continuity conditions (C^0, C^1, C^2, G^0, G^1, G^2) does the spline fulfill at the point $u = 1$?

Segment 1:
$x_1(u) = u^2 - u$ $\quad 0 < u \leq 1$
$y_1(u) = 3 - u$

Segment 2:
$x_2(u) = -2u^2 + 6u - 4$ $\quad 1 < u \leq 2$
$y_2(u) = u^3 - 2u^2 - u + 4$

(8p)

4. Mapping techniques

a) A textbook in CG suggests the following formula for mapping a texture onto a cylinder:

$s = 2/\pi * \tan^{-1}(y/x)$
$t = z$

However, this only works for a part of the cylinder. Modify this formula to map the texture around the entire cylinder. Both coordinates should be normalized to the interval [0, 1].

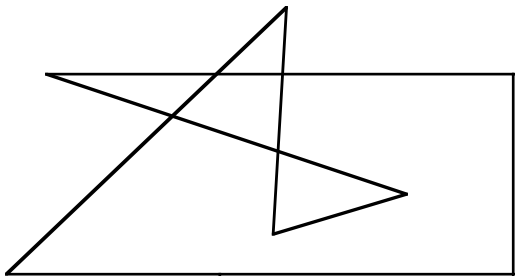
b) Explain why perspective correct texture mapping is much more computationally intensive than affine texture mapping. How can you overcome this problem?

c) Explain how mip mapping works. Why doesn't mip mapping always produce perfect results?

(7p)

5. Miscellaneous

a) When filling polygons in 2D graphics, what is the difference between using the odd-even test and the winding number test? Use the figure below for clarifying the difference.

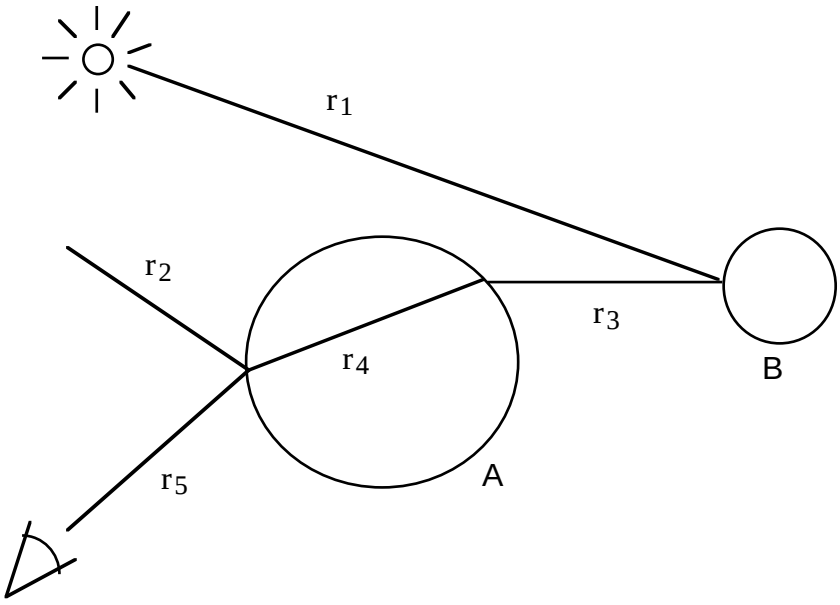


b) What is the advantage of triple buffering, over double buffering?

(5p)

6. Light, shading and ray-tracing

a) The following figure shows a simple scene with five rays cast in a ray-tracing procedure. The object A is transparent, glass-like (no reflections other than perfect mirroring), and the object B is non-transparent and diffuse. There are *no other objects* in the scene! Outline how the final pixel value is calulated from these rays. What rays give a contribution? What is the point of the ray r1?



b) In the ray-tracing above, how is the ray r2 calculated?

c) Write a formula for the three-component light model (Phong model), and define all symbols using a figure.

(7p)

7. Collision detection

a) What is the difference between AABB and OBB? Compare both how they are defined and advantages and disadvantages in practical use for collision detection.

b) In the narrow phase, what tests are necessary to determine whether two polygon models intersect?

(5p)

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) Show, from a computation time point of view, using the plane equation and other geometrical formulas, that the depth buffer (Z buffer) should hold values proportional to z^{-1} rather than z.

c) Outline the principle for portals. For what kind of environments is this suitable?

(7p)