Exam Computer Graphics Class

Name:

Student Number:

Date: April 14, 2008 Time: 9:00–12:00

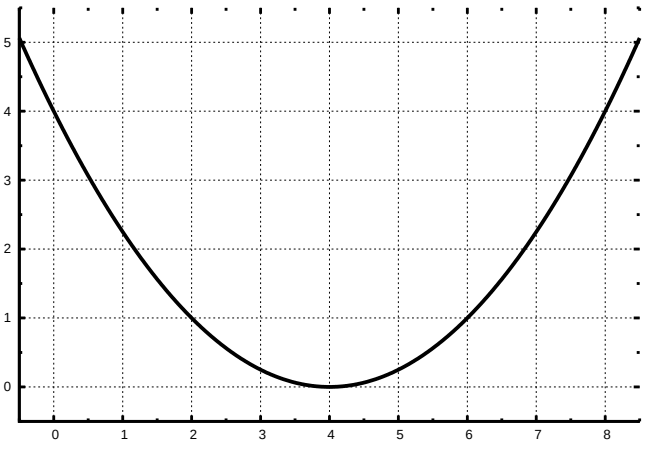
Instructions, read carefully: First, fill in your name and student number above. Also add your name and student number to all of the extra sheets of paper that you use. You have 3 hours to answer the questions. Please answer in English if at all possible, write clearly. When in doubt, use a small sketch/illustration to make your point. When you hand in your answer sheets, hand them in with the exam question form.

Question 1: Bresenham Midpoint Algorithm (25 points)

One important problem in computer graphics is to scan-convert a curve such as a straight line, a circle, a parabola, or a general function, i. e., to compute the pixels to set on a raster display that are to represent this curve. Given the function of your teacher's currently favorite parabola (also shown on the left):

$$f(x) = \left(\frac{x}{2} - 2\right)^2,$$

Bresenham's midpoint algorithm can be used to scan-convert this function precisely and efficiently. For this purpose, the parabola is first split in half at the symmetry axis ($x = 4$), and each of the sides again into 2 segments which meet where the slope of the curve is equal to 1.



a) Looking at the positive half of the curve ($x \geq 4$), between which pixels (relative to the pixel previously set) is the decision made for each of the above mentioned two segments (mark and name the two segments as Segment A and Segment B in the above illustration, and then refer to them in your answer)? (2 points)

b) Derive the decision variable d and the two increments of the Bresenham midpoint algorithm for the first segment (slope < 1). (15 points)

c) Derive the second order differences. (8 points)

Question 2: Homogeneous Coordinates (4 points)

a) What are homogeneous coordinates and why are they necessary? (2 points)

b) What is the equivalent in homogeneous space of a coordinate in regular space? (2 points)

Question 3: Transformation Matrices (10 points)

a) Give the transformation matrices for 2D non-uniform scaling and translation in homogeneous coordinates. (4 points)

b) Derive the transformation matrix for a counter-clockwise rotation around the coordinate origin by an angle ϕ in homogeneous coordinates. Use a sketch to support your explanations. (6 points)

Question 4: Transformation Order (1 point)

Using column vectors, write the computation of a transformed vertex P' from an original vertex P if you want to achieve first a translation T_1, then a scaling S, then a rotation R, and finally another translation T_2 (give it in the form $P' = A \cdot B \cdot \ldots \cdot N \cdot P$).

Question 9: z-Buffering (10 points)

Explain the z-buffer algorithm.

Question 10: Phong Illumination Model (10 points)

To be able to render a scene, it is necessary to determine what light gets reflected in which way at a location on the surface of an object.

a) Which three aspects of light reflection does the Phong illumination model capture and which phenomena of real physical reflection do these represent? (6 points)

b) Give the formula of the Phong illumination model. (3 points)

c) How do you achieve a smaller but more pronounced highlight, i. e., which parameter do you have to change and how? (1 point)

Question 11: Shading Techniques (10 points)

a) What is shading in computer graphics? (2 points)

b) Explain Gouraud and Phong shading, comparing the two approaches. Name problems and advantages for each approach. (8 points)

Question 13: Color and Color Representation (10 points)

In computer graphics, color is usually specified using three values.

a) What is color? (1 point)

b) Why do we generally use three values to represent color? (2 points)

c) Can three values represent all perceivable colors? Why/why not? (5 points)

d) What are metamers? (2 points)

Question 16: Cohen-Sutherland Clipping (10 points)

Describe the Cohen-Sutherland algorithm for clipping in 2D. Draw a sketch to support your explanations.

Question 18: Raytracing (10 points)

a) Describe the general approach of raytracing using very general pseudo-code. (5 points)

b) Which aspects of physical light behavior does raytracing capture particularly well, which does it not capture well? (2 points)

c) Name and give a short explanation for at least three ways to reduce the number of intersection tests in raytracing and to accelerate it or to improve. (3 points)