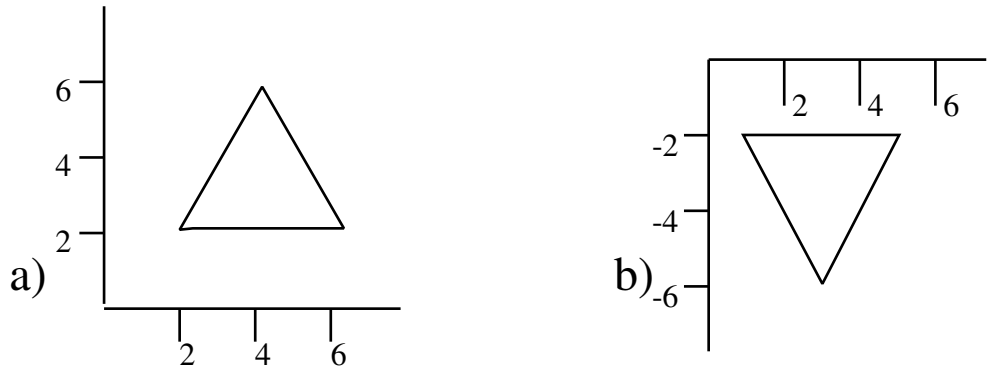
Department of Scientific Computing
Bo Nordin (bosse@cb.uu.se, 183470)

Examination, Computer Graphics MN1, 950114

Allowed time: 5 hours
No books allowed, only paper, pen, and dictionaries
Enter your name on all papers that you hand in, do not use red
Use figures to illustrate your answers, if you wish.
"Describe" means "describe in words, name difficulties, etc. ", *not* "implement".
You need 18 points to pass the exam.

1a) What are homogeneous coordinates and why are they used? Give an example which clearly demonstrates the benefits of using them. (2p)
1b) Explain the concepts window and viewport and describe how they are related. What's the use of windows and viewports? Illustrate with examples. (2p)

2. The 2D object in figure a) below is to be transformed to its position in figure b). How is this accomplished? What steps are needed? Show the transformation matrices for each step, and also for the complete transformation. There are two fundamentally different ways to do the transformation. Describe both; matrices are required for only one of the two cases (4p)



3a) What do the concepts request, sample, and event mode mean? In which part of computer graphics are they used? (2p)
3b) How, in principle, does an X-Windows application look? Which of the three modes above are used? Requests in the X protocol are of two fundamentally different kinds. Which? Give examples of request of both types. Why is it important to differentiate between the two types of requests? (2p)

4 In order to be able to display primitives on raster graphics workstations, a scan conversion must be done. What does scan conversion mean and why is it necessary. When drawing a circle, one can use the formula $x^2 + y^2 = R^2$ (where R is the radius of the circle) by solving for y and then loop over x. However, this does not work very well. What happens? Discuss possible improvements of the algorithm and describe and algorithm for efficient scan conversion of circles. (5p)

5. Graphics packages must be capable of filling an arbitrary polygon with an arbitrary colour or pattern. Describe a well-known, efficient, algorithm that does this. How does one fill a polygon with a pattern? (4p)

6 Natural objects (forests, clouds, mountains, etc.) are not easily described with methods based on Euclidean geometry. Instead one can use fractals, for instance. What is the fundamental difference (computationally) between modelling based on geometric methods and modelling with fractals? An important concept in fractal geometry is the fractal dimension. How is it defined? Use illustration, if you wish. Koch's snowflake is an example of a deterministic fractal. How does it look, and what is its fractal dimension? Nature, however, isn't quite that deterministic. How are images that are generated with fractals made to look more natural. How are the veins of a leaf or the tops of a mountain range made to vary, for instance? (4p)

7. Shading is important in order to accomplish realistic images. One can use constant shading or interpolated shading. What is the difference? Under what circumstances does constant shading produce correct images? Gouraud shading and Phong shading are two methods for interpolated shading. How do they work? In particular, what is the difference between the two, and how does this difference affect the end result? (4p)

8a) 3D viewing involves a number of coordinate system. Which? How do they relate? What operations "translate" between the various coordinate system? Leave out illumination, shading, and visible surface elimination in your description. (3p)
8b) Assume the we want to remove hidden surfaces and take illumination and shading into account. How does the rendering pipeline (described above in 8a) change if 1) the z-buffer algorithm and Phong shading is used and 2) ray tracing is used? (3p)

9. When writing pixels in a frame buffer it is possible to let what is written into the buffer be a bitwise logical operation between the old pixel value and the new one. Give examples of a few common operations and describe how they can be used. (2p)

10. CRT and LCD screens are two common types of screens for computer graphics. Briefly explain how they work and specify advantages and disadvantages of the two types. (3p)