

ENEL/CPSC 555 Mid–Term Fall 1996

Name (first, last):

Student I.D.

Official Use
1
2
3
4
Total

All questions carry equal weight.

Answer question 1 and as many questions as you can in the time allowed. Use the last 5 minutes to read over your answers. Full marks may be obtained for correct answers to 3 questions.

1. Computer Graphics

For part **a** circle one of the following (the most appropriate answer).

a) Homogeneous matrices are used in computer graphics because:

- It is more efficient to perform calculations in a higher dimensional space.
- Rotations, scaling and translation matrices may be concatenated.
- All matrices thus used are orthogonal.

For parts **b** and **c** circle the most appropriate answer(s)

b) An orthogonal matrix used in 3D computer graphics is:

- An affine transformation.
- A rotation matrix concatenated with any rotation or translation matrix.
- The row vectors of the upper left 3x3 matrix are unit vectors.
- These row vectors are orthogonal to each other.
- Each of these row vectors will be rotated by the rotation matrix into one of the principle axes.

c) The shape **and** continuity of a B-spline curve may be altered by changing:

- The knot spacing in parameter space.
- The positions of the control points.
- By making successive knots coincident.

2. Hardware/Colour Tables/Scan Conversion

a) A raster graphics system has 3 bits/pixel and uses an 8 bit wide colour table. How many colours can be displayed simultaneously? Chosen from what size palette (i.e. how many different colours can be displayed?) The figure 'X' is set into the raster memory using a single bit plane, i.e. the least significant bit is set in bit plane zero. A '0' is displayed in bit plane 1. Show with the aid of a diagram how the colour table can be loaded to display the 'X'? How can the colour table be loaded to display the '0'? How can the colour table be loaded to display both images?

b) The discriminator (decision variable) d in the mid–point circle algorithm is the value of the function at the midpoint. Given a pixel $A(x_p, y_p)$ how is the decision variable used to decide between pixel $B(x_p+1, y_p)$ and $C(x_p+1, y_p-1)$? If pixel B is chosen how is d incremented. if pixel C is chosen how is d incremented. (Show your calculation for d).



over

3. Hierarchies and Clipping

a) A hierarchical computer graphics system is used to design machine parts. A *gizmo* consists of 2 wheels and an axle, matrices A, B and C are used to transform each of the components to form the gizmo. A *bogey* uses matrices D,E and F to position the 2 gizmos and a cube which form the bogey. A *vehicle* consists of 2 bogeys and a cube and uses matrices G, H and I to transform each part. The primitives in the system are the cube, axle and the wheel. Draw a diagram of a suitable data structure for a vehicle, which takes advantage of object instancing. Which matrices would be applied to the wheel to transform it into the correct position and orientation on a vehicle? (Use the first wheel of the first gizmo of the first bogey). State the order of matrix multiplication and whether points in the system are represented as row or column vectors.

b) The planar polygon defined by the coordinate pairs (5, 5) (−1, 5) (−1, 1) (1, 1) (1, −2) (5, −2) is clipped against a square of side 4 units (0, 0) (4,0) (4,4) (0,4). Using the Sutherland Hodgman polygon clipping algorithm, draw the polygon as it is clipped against each side of the square. (see Figure 1)

Figure 1:



4. Splines

a) What is meant by the term basis function? Derive the B-Spline basis functions from the B-Spline matrix given below.

$$M_{Bs} = \frac{1}{6} \begin{vmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 0 & 3 & 0 \\ 1 & 4 & 1 & 0 \end{vmatrix}$$

b) A Bezier curve segment has the following geometry vector:

$$\begin{bmatrix} (0,0) \\ (4,4) \\ (12,4) \\ (16,0) \end{bmatrix}$$

It is required to subdivide the curve into two parts so that the shape of each part may be edited. Show how this can be done so that the result is two Bezier curve segments. Calculate the geometry vectors of the two segments.

