Question 1: Fill algorithms (20)

(b) What is the simplest implementation of filling? (1)

(c) Why is this approach unsatisfactory? (1)

(d) What is the difference between a 4 connected and an 8 connected fill algorithm? Illustrate with a diagram. (2)

(e) What implication is there to using either 4 or 8 connected fill? Consider what happens when the two algorithms reach a sloping line one pixel wide. (3)

Question 2: Scan conversion (30)

(a) What is scan conversion? (1)

(c) What assumptions does midpoint algo nake about the ordering of the points and the slope of the line? (2)

(d) What can be done in the cases where these conditions are not true? (2)

(e) With a sketch illustrate which pixels are drawn for an example line with slope greater than 0 and less than 1. Do not make precise calculations, simply illustrate a general appearance. (2)

(f) It is possible to do the scan conversion calculations using entirely integer operations. Why and how is that possible? (1)

(g) The algorithm is based on the implicit function of a line. Write down the implicit function of a line and define and explain the components of the equation. (4)

(h) How is the implicit function useful in determining which pixel to draw next? (2)

(i) Calculating the value of the implicit function still requires the calculation of a dot product - how is this avoided? Show your working. (4)

(j) The code to do this integer line drawing is:

```
void draw_line ( int x0, int y0, int x1, int y1 ) {
    int x, y = y0;
    int dx = 2*(x1-x0), dy = 2*(y1-y0);
    int dydx = dy - dx, d = dy - dx/2;

    for ( x = x0 ; x <= x1 ; x++ ) {
        draw_pixel ( x, y );
        if ( d < 0 ) { d += dy; }
        else { y += 1; d += dydx; }
    }
}
```

Annotate this code to explain what each variable represents and what each command does. (6)

(k) How many integer operations are required per pixel in this code? (1)

Question 3: Visibility algorithms (20)

(a) In the display of 3D scenes what is the visibility problem? (1)

(d) Explain the two most significant problems of Painter's algorithm.

(e) The z-buffer algorithm also solves the visibility problem. Explain its operation with pseudo-code, including its initialization step and the ranges of the loops. (5)

(f) Where might this algorithm have problems? (1)

(g) The z-buffer, together with the stencil buffer can be used to render shadows in 3D scene.
Explain the principle of this algorithm, and what is done in each of the three passes. No pseudo code required.

Question 4: Viewing (20)

(a) What transformations are required to place a camera at any suitable position to view a scene? (2)

(b) What three (mainly common sense) considerations go into the positioning of the camera in a scene? (3)

(c) Describe a simple view specification scheme in which the three requirements that you listed above are met. (3)

(d) Describe how each of the above sections of the viewing scheme is implemented. Explain how each component of the transformations required can be calculated.

Question 5: Illumination (40)

(a) What is light and what gives it different colors? (2)

(b) Why do we encode light as only three numbers? And why does that work?

(c) What would be two implications for television if it had to reproduce the whole spectrum of light? (2)

(d) What is the difference between additive and subtractive color? (2)

(e) What three components of illumination (not color) are used to calculate shading for an opaque surface? (3)

(f) What two simple attenuation effects can be added to these illumination calculations? Explain the physical reasons for using these effects and give a simple equation if possible. (5)

(h) It is very difficult to compute the correct illumination terms using physical models and so approximations are used. A commonly used illumination equation is from Phong:

$$I = I_a k_a + f_{att} I_p (k_d \cos\theta + k_s \cos^n \alpha)$$

Explain all the values and terms in the above equation. (10)

(i) The above equation refers to a single light source - how is the equation extended for multiple light sources? (2)

(j) How is color implemented using the above equation? (1)

(k) The above equation still does not produce very realistic images - what do the images look like and why are they unrealistic? (1)

(l) Texture mapping can be used to improve images. There are several different ways of using it, name four of them. (4)

(m) Briefly explain how texture mapping is implemented on the GPU.

(n) One method of texture mapping generates the appearance of a rough surface on an actually planar surface. State how this is done and describe the anomaly that this approach produces. (2)