There are five questions on this paper. Answer THREE questions.

1.

(a) Define a Binary Space Partition (BSP) tree in the context of a 3D scene constructed from planar polygons, in particular describing the BSP tree data structure.

[5 Marks]

(b) In the context of an object hierarchy, what are local coordinates, the local transformation matrix, and the current transformation matrix?

[5 Marks]

(c) Suppose that all objects are defined in their own local coordinate system. Describe in detail how to build a BSP tree if it is required that polygons are never transformed to World Coordinates (that is, build a BSP tree while keeping the coordinate systems in which each object is described as the local coordinate system in which it is defined).

[10 Marks]

(d) Explain the potential advantage of building a tree using the method described in (c) compared with first transforming each object to World Coordinates and then building the tree.

[5 Marks]

TURN OVER

2.

(a) Define the usual parameters that control a virtual camera (eg, the View Reference Point - VRP - is one such parameter).

[7 Marks]

(b) Given the parameters in (a) describe in detail the derivation of the matrix that transforms an object's coordinates from World Coordinates to a coordinate system about the camera (the Viewing Coordinate System) for a perspective projection.

[10 Marks]

(c) Suppose there are three distinct points in 3D space p_0, p_1 and p_2. A virtual camera is moving along the paths from p_i to p_{i+1} (i=0,1,2) with $p_n \equiv p_{n \bmod 3}$. When the camera is on the path p_i to p_{i+1} it is "looking" along the corresponding vector. When the camera reaches the end of a particular path, it stops, and gradually rotates through the angle defined by the successive vectors, until it is facing in the direction given by the next vector. The up-direction of the camera is chosen so that it is perpendicular to the plane defined by the three points. Describe an algorithm for moving the camera continuously through this path, carefully describing any functions that you assume.

[8 Marks]

CONTINUE

3.

(a) Find the plane equation of the polygon (P) which has vertices (0,0,0), (1,0,0), (1,1,1), (0,1,1). The order of points is given so that when looking at the front of the polygon, the points are in anti-clockwise order.

[5 Marks]

(b) Suppose that there is a point light source at (0.5,-2.5,4.5). The light source is pure white, and there is a background ambient light of (R,G,B) = (0.1,0.1,0.1). The reflection coefficients for the polygon surface are:

ambient: (R,G,B) = (0.1,0.1,0.1)
diffuse: (R,G,B) = (1,1,0)

Find an expression for the (R,G,B) intensity for the centre of this polygon.

[10 Marks]

(c) Describe Gouraud shading in the context of the z-buffer algorithm for hidden surface removal for a scene based on planar polygons.

[10 Marks]

4. (a) Describe in detail the ideas and principles involved in ray tracing.

[7 Marks].

(b) Provide a pseudo code or other description of the ray tracing algorithm.

[8 Marks].

(c) Outline the Cohen-Sutherland algorithm for clipping a line against a 3D cuboid of the form $x\min \le x \le x\max, y\min \le y \le y\max, z\min \le z \le z\max$, and explain in detail how this might be used in the context of a method for accelerating ray tracing.

[10 Marks]

TURN OVER

5. (a) Define the odd-even and winding number rules for specifying whether a point is inside an arbitrary closed polygon.

[5 Marks]

(b) The following sequence of points describes a polygon: (0,0), (8,16), (-2,8), (2,8), (-8,16), (closing the polygon at (0,0)). Discuss whether the following points are "inside" or “outside” of the polygon, giving the reasons for your decision in each case:

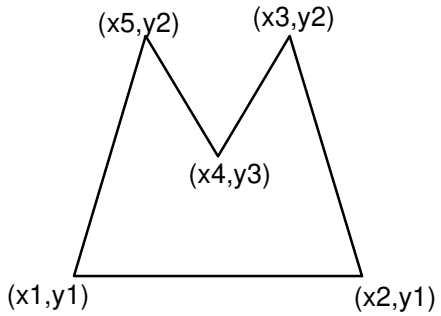
(i) (0,5)

(ii) (0,9)

[4 Marks]

(c) Write out fully a procedure implementing an algorithm for scan-filling the class of shape shown below.

[12 Marks]



In these shapes the following inequalities are true

$x1 < x5 < x4 < x3 < x2$

and

$y1 < y3 < y2$

(d) Describe how your algorithm differs from the general polygon filling algorithm, and the justification for those differences.

[4 Marks]

END OF PAPER