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

1.

(a) The point p is in world-coordinates. For example, it might be the vertex of a polygon. Describe the pipeline that leads to p being mapped ultimately to a pixel on the display.

[5 Marks]

(b) The parameters for a camera are View Plane Normal (1,1,1), View Up Vector (0,0,1) and View Reference Point (0,0,0). The centre of projection is at (0,0,-1), and the view plane distance is 0. What is the projection of the point (0,1,0) on the view plane?

[7 Marks]

(c) What is ‘canonical viewing space’? Describe in detail the Sutherland-Hodgman algorithm for clipping a polygon to the view volume in this space.

[8 Marks]

(d) Explain why it is essential that clipping take place before projection.

[5 Marks]

2.

(a) Define each of the following terms in the context of an object hierarchy: local coordinates, world coordinates, local transformation matrix, current transformation matrix, object, child.

[6 Marks]

(b) Describe a data structure that can be used to model an object hierarchy. Show how to implement the function setLocalTransformation. Describe how all coordinates in a scene would be converted from local coordinates to world coordinates.

[9 Marks]

(c) Suppose there is a pyramid which has a square base with opposite corners (-1,-1,0) and (1,1,0), and has height 1, i.e., the apex is at (0,0,1). Describe how to construct an object hierarchy which has a sequence of n such pyramids piled on top of one another, where all the bases are parallel to one another, and the centre of the base of the ith pyramid is exactly equal to the apex of the (i-1)th pyramid.

[10 Marks]

3.

(a) Describe in detail how you would compute whether an arbitrary point on a plane is inside a convex 2D polygon on the same plane.

[7 Marks]

(b) Describe in detail an algorithm for filling (raster scanning) an arbitrary 2D polygon.

[10 Marks]

(c) Describe in detail how the general algorithm can be modified in the case that the polygon is convex.

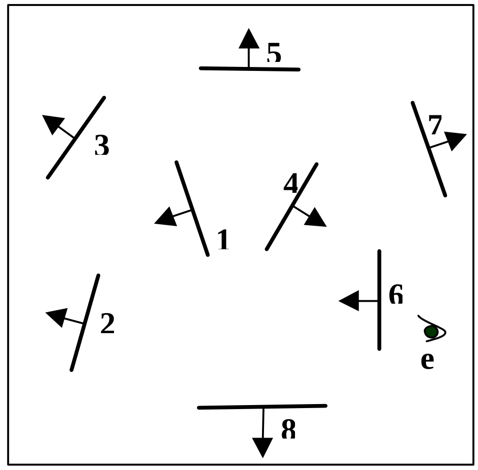
[8 Marks]

4.

(a) Explain what a BSP tree is and how it is used in rendering.

[5 Marks]

(b) For any scene, a number of different valid BSP trees can be generated, by choosing the polygons to form the partitions in a different order. In the figure below assume that line segments represent polygons (seen from above, edge-on), with the arrows indicating the front of each polygon. Give the two trees created by selecting the polygons in this order:



for T_1: 1, 2, 3, 4, 5, 6, 7, 8

for T_2: 8, 7, 6, 5, 4, 3, 2, 1

Which of the two should be preferred for rendering and why?

[9 Marks]

(c) Given a BSP tree T and a viewpoint v give the pseudocode for a procedure to find the "closest" polygon (front most in terms of visibility) as seen from v.

[6 Marks]

(d) Traverse each of the two trees built above and get the back-to-front order from the eye position *e*. Verify that each tree gives the correct order. Explain your answer briefly.

[5 Marks]

5.

(a) Describe how images are computed in ray tracing. Give an outline of the algorithm for tracing a ray.

[10 Marks]

(b) Assuming monochromatic light, compute the intensity of pixel *p* in the figure below. Doted lines labelled **n** are the normals to the surfaces.

Intensity of light L = 1.0, Intensity of ambient colour = 0.3, Background colour = 0.4

Material of surface **a:**

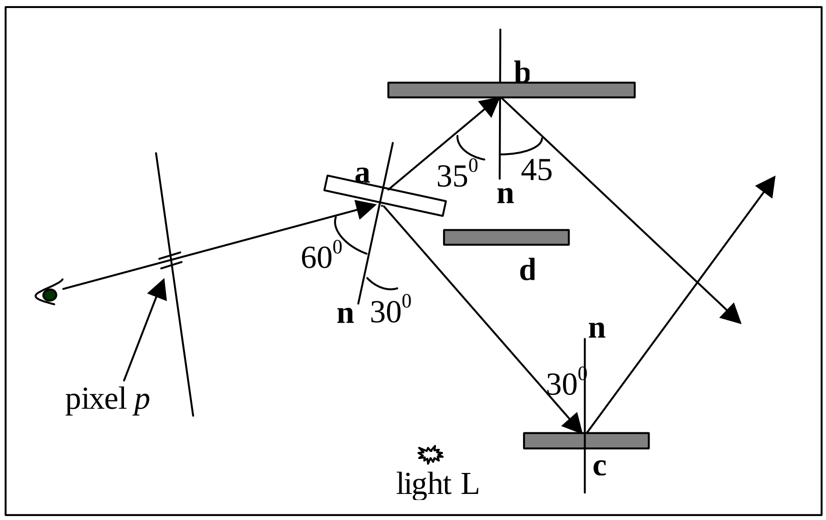
$k_a = 0.2$

$k_d = 0.2$

$k_r = k_s = 0.3$

$k_t = 0.3$

m (shininess) = 2



Material of surfaces **b, c** and **d**:

$k_a = 0.2$

$k_d = 0.3$

$k_r = k_s = 0.5$

$k_t = 0$ (surfaces are opaque)

Also cos(15) = 0.96, cos(30) = 0.87, cos(35) = 0.82, cos(45) = 0.71, cos(60) = 0.5.

[8 Marks]

(c) Compare ray-tracing with the other main global illumination algorithm, radiosity. In what circumstances is one preferable to the other?

[7 Marks]

END OF PAPER