This question paper consists of 6 printed pages, each of which is identified by the Code Number COMP3811.

This is a closed book examination. No material is permitted. Use of a non-programmable calculator is allowed.

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School of Computing

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COMP3811

Computer Graphics

Answer 3 out of 3 questions

Time allowed: 2 hours

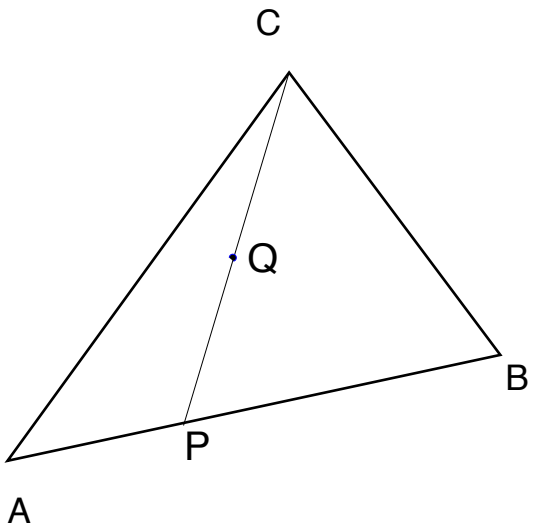

Figure 1: A triangle.

Question 1

(a) Give the definition of an affine transformation. You can give a formulation in plain English or use formulae. **[2 marks]**

(b) Give the parameterised line that passes through points $P = (3, 4)$ and $Q = (-6, 1)$. Find the coordinates of the point R that is on the line, such that the distance PR is half that of RQ.

[4 marks]

(c) Express the same line in normal form. Use the half plane test to show that the point $(5, 2)$ is to the right of the line.

[6 marks]

(d) Given triangle ABC (Figure 1), show that you can write the coordinates of point Q as: $Q = (1 - s)(1 - t)A + (1 - s)tB + sC$, and that the sum on the right hand side is an affine combination.

[4 marks]

(e) An octahedron centered at the origin has eight faces. One face is determined by the points (1,0,0), (0, 0, 1) and (0, 1, 0). Find the outward normal vector of this face. You may use any geometrical argument, or use the cross product, but must explain your answer.

[4 marks]

[question 1 total: 20 marks]

Question 2

(a) You are creating an app for a chocolate factory. Their idea is to render a number of chocolate eggs, arranged in a rectangular array on a football field. If you click on an egg, the egg must jump up. A colleague already has implemented a method for converting mouse clicks into world coordinates. You already have created a sequence of vertical translations to model the jump animation. Explain how you would organise your rendering code to make use of the available methods.

[4 marks]

(b) In 3 dimensional space, consider the line parallel to the y-axis through point $(2, 0, 1)$. Give the transformation corresponding to a 60° clockwise rotation with this line as axis as a product of matrices in homogeneous coordinates. If you cannot do this, write out the required transformations as a sequence of 3D transformations.

[4 marks]

(c) Consider the affine transformation that transforms the small house-like figure in Figure 2 into the larger distorted figure. The coordinates of the vertices that make up the figure before and after transform are given in Table 1. Determine the affine transformation in terms of a 3×3 matrix.

[4 marks]

(d) Describe the simplified model of a camera that is used in OpenGL.

[2 marks]

(e) Describe the sequence of transformations leading to the parallel view volume and describe the role of this volume in the graphics pipeline. It is not necessary to write the transformations in matrix form.

[6 marks]

[question 2 total: 20 marks]

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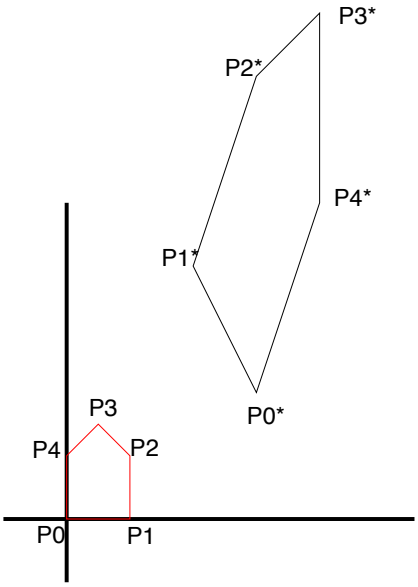

Figure 2: An affine transformation transforms the points P_i to P_i*.

Point	From	To
P0	(0,0)	(3,2)
P1	(1,0)	(2,4)
P2	(1,1)	(3,7)
P3	(0.5,1.5)	(4,7.5)
P4	(0,1)	(4,5)

Table 1: Table of vertex transformations under the affine transformation shown in Fig. 2.

Question 3

(a) Briefly discuss the Phong reflectance model as used in OpenGL, and explain the role that the normal vector plays in the shading process.

[6 marks]

(b) Explain the difference between flat shading and Gouraud shading.

[3 marks]

(c) The OpenGL documentation states that the current world transform matrix is applied to vertices. On the other hand, normal vectors are transformed according to the transpose of the inverse matrix. Why is this different? Show that it is the correct solution.

[6 marks]

(d) Explain what texture mapping is and why we use it. Give an example of a situation where texture mapping is appropriate and state why.

[5 marks]

[question 3 total: 20 marks]

[grand total: 60 marks]

END