UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2005

BEng Honours Degree in Computing Part III
MSc in Computing Science
MEng Honours Degree in Electrical Engineering Part IV
BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
MSci Honours Degree in Mathematics and Computer Science Part IV
BSc Honours Degree in Mathematics and Computer Science Part III
MSci Honours Degree in Mathematics and Computer Science Part III
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute
This paper is also taken for the relevant examinations for the Associateship of the Royal College of Science

PAPER C317=I3.16=E4.32

GRAPHICS

Monday 9 May 2005, 14:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

1 Shading of Planar Surfaces

Any point in a triangle can be written in vector form as:

$\mathbf{P} = \mathbf{P}_1 + \alpha(\mathbf{P}_2\text{-}\mathbf{P}_1) + \beta(\mathbf{P}_3\text{-}\mathbf{P}_1)$

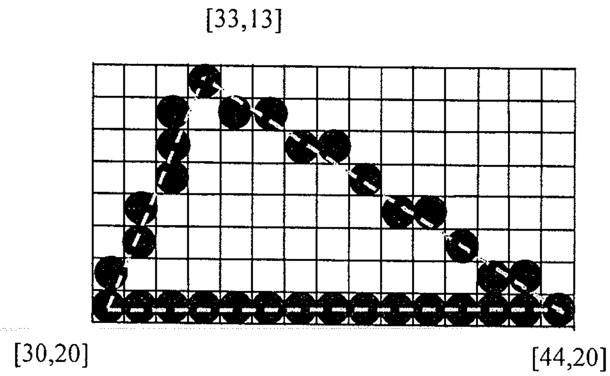
where

$\mathbf{P}_1$, $\mathbf{P}_2$ and $\mathbf{P}_3$ are the vertices of the triangle and α and β are scalar parameters in the range [0..1]

a Given that the calculated light intensities at the vertices have been found to be I1,I2 and I3 respectively, derive an expression for the intensity at a general point **P** in the triangle using Gouraud (interpolation) shading.

b Given that the vertices of the triangle are given in two dimensions in integer pixel addresses, explain how a fast algorithm can be used first to calculate the shade values at the edge pixels and then to calculate the shade values of the interior points.

c A projected triangle has pixel addresses as shown in the figure:



The intensities calculated for the vertices are:

Point	Intensity
[30,20]	90
[44,20]	160
[33,13]	69

Using your algorithm of part b calculate the intensity at pixel [38,18].

d Check to see that your formula in part a gives you a similar result.

e Explain why Gouraud shading may not be effective for rendering highly specular surfaces.

The five parts carry equal marks.

2 Ray tracing

a Explain which effects can be achieved with ray tracing and how these effects are created. Which effects cannot be created with ray tracing?

b Explain the difference between primary rays and secondary rays.

c Describe the use of two space subdivision methods for ray tracing and describe how they can be used to accelerate ray tracing.

d A ray originates at point **P** and is parallel with unit direction vector ***d***. A square shaped facet is given by one of its corner points **P1**, two mutually perpendicular unit direction vectors ***u1*** and ***u2*** and the length of the side of the square s. Show in detail how you can calculate the intersection between the ray and the square shaped facet. Note that the other corners of the square can be written as **P2** = **P1** + s ***u1***, **P3** = **P1** + s ***u2***, and **P4** = **P1** + s ***u1*** + s ***u2***.

e In a concrete example, a ray starts at the origin and has a direction vector ***d***=(0, 0, 1). The square shaped facet is defined by **P1**=(-1, -1, 10) and ***u1***=(1, 0, 0), ***u2***=(0, 1, 0). The sides of the square have length s=5. Calculate whether the ray intersects the square shaped facet.

The five parts carry, respectively, 20%, 10%, 20%, 40%, 10% of the marks.

3 A three dimensional graphics scene made up of polygons is to be drawn in perspective projection viewed from the origin, with the direction of view along the z-axis.

The viewplane has equation z=10, and the viewing window defining the world coordinate system has corners given by the points:

{10,10,10}, {10,-10,10}, {-10,10,10} and {-10,-10,10}.

One of the polygons that makes up the scene is a triangle with corners at the following three dimensional points:

P0={20,40,50}, P1={10,-10,50}, P2={120,40,80}

The scene is to be drawn in a window whose top left hand corner is the origin, and whose bottom right corner is the pixel [300, 200]. (Note that the positive y direction is down the screen which is the normal convention in the Windows operating system)

a What are the x and y co-ordinates of the projections of the points P0, P1, and P2 onto the viewplane in world co-ordinates?

b Sketch what would be seen in the window on the screen.

c What is the matrix that calculates the projection, using homogenous co-ordinates?

d Calculate the values of A,B,C and D in equation pair that carries out the 2D normalisation transformation between the world co-ordinate system defined by the window, and the actual pixel addresses:

Xpix = A x + B
Ypix = C y + D

e If the user carries out a zoom operation. This does not change the position or pixel resolution of the window, but which magnifies the view by a factor of 2 in both the X and the Y axes, while leaving the origin at the same place. How do the values of A B C and D change?

The five parts carry equal marks.

4 Anti-Aliasing

a Explain, with a suitable diagram, what is meant by an alias frequency. In what way do alias frequencies manifest themselves in raster images?

b Explain how the effect of alias frequencies can be reduced by means of a low pass convolution filter. Suggest a suitable filter for this purpose.

c Explain how super-sampling can be used to reduce alias effects in raster images.

d What are the advantages and disadvantages of the anti-aliasing methods discussed in parts b and c?

e Suggest why alias effects can be particularly problematic when mapping texture onto polygons.

The five parts carry equal marks.