UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2003

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
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

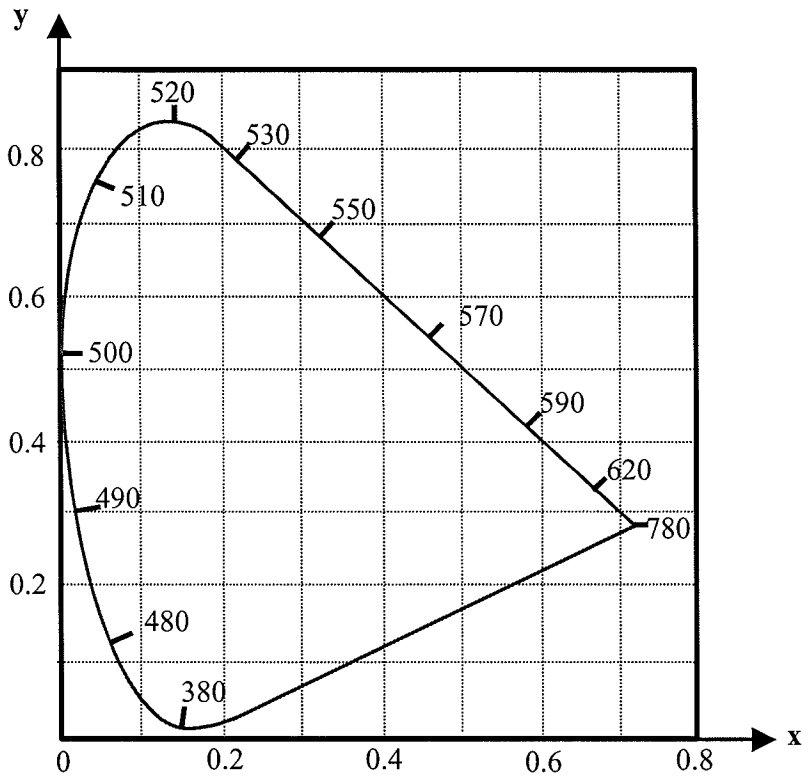
Thursday 8 May 2003, 14:30
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

1. Colour

The standard CIE chromaticity is shown below:



a What are the normalised x (red), y (green) and z (blue) values for a pure colour defined as having a wavelength of 590 nanometers and what are the x, y, z values of its complement colour?

b What are the normalised x, y, z values for a colour shade whose principal colour is at 590 nanometers and its saturation is 50% ? Show your work.

c Briefly describe additive and subtractive colour schemes. Explain the main differences of both schemes. What are their advantages and their disadvantages?

d A RGB computer display is calibrated by the standard CIE values as

red = (0.8, 0.1, 0.1)
green = (0.2, 0.7, 0.1)
blue = (0.2, 0.2, 0.6)

When executed, the procedure **SetColour(R, G, B: int)** produces a colour shade on the screen with the intensities of the three basic colours ranging from 0 to 255. What are the normalized CIE (x, y, z) values of the colour shade which appears on the screen after the call **SetColour(25, 25, 25)** is executed?

The four parts carry equal marks.

2 Warping and Morphing

a Explain how morphing combines warping and blending to create smooth transitions between two images.

b Briefly describe the Beier-Neely algorithm for warping and morphing.

c A two-dimensional free-form deformation based on linear B-splines is defined by a 5 x 5 control point matrix, which is given below. For an image of size 120 x 80 pixels show in detail how to calculate the new location of a pixel (x,y) = (45, 70) after warping.

(-1, 4)	(-3, 7)	(4, 7)	(0, 1)	(2, 3)
(-2, 7)	(-2, 9)	(3, 1)	(2, -2)	(2, 2)
(5, 3)	(3, 8)	(7, 2)	(2, 1)	(3, 1)
(3, 2)	(2, 9)	(3, 8)	(3, 4)	(3, 5)
(-1, 3)	(-2, 3)	(2, 2)	(8, 3)	(-4, 2)

d A friend is programming a new computer game and has asked you to design an animation that morphs one face into another face. Your input data consists of two 3D datasets describing the different faces. Each dataset consists of a 3D surface model represented by a set of vertices as well as a set of 2D texture coordinates for each vertex and a RGB texture map. Describe the key steps necessary to generate a smooth morphing between both faces.

The four parts carry, respectively, 20%, 30%, 30% and 20% of the marks.

3. Raster Algorithms

In a low level graphics package the procedure SetPixel(x,y) which will set the pixel in a frame buffer to the currently chosen colour, has been implemented. It is now necessary to write a procedure Drawline(xs,ys,xf,yf) which draws a single pixel line between pixel (xs,ys) and pixel (xf,yf).

a Write the pseudocode implementation of a differential line drawing algorithm that will draw a line in the first octant. (In the first octant, the gradient of the line is between 0 and 1)

b Explain how your algorithm could be adapted to draw lines in the other octants.

c. A procedure DrawCircle(int xc, int yc, int r) is to be implemented to draw circles using a line scan algorithm. The plan is to calculate the circle points with the circle centered on the origin and then translate the points by (xc,yc). Write a pseudocode implementation of this procedure. Remember that for the best effect you will need to use horizontal scan lines if $|x|>|y|$ and vertical scan lines otherwise.

d. A curve $4x^2 - 2x - 2y = 0$ is to be drawn using a general purpose raster algorithm. The starting point is pixel address {10,190}. Use a suitably labelled sketch find the adjacent pixels to the starting point.

The four parts carry, respectively, 20%, 20%, 30% and 30% of the marks.

4. Viewing Transformations

A graphics scene is defined in a left hand coordinate axis system. This forms a viewing space in which the positive y axis is upwards, the positive x axis points to the right, and the positive z axis is the viewing direction. All transformations in this question are assumed to use pre-multiplication of the matrix. They are of the form **Pt** = **P** * $\mathbb{M}$.

a Explain why homogenous coordinates are used to generate three dimensional transformation matrices for interactive graphics animation.

b A line from the origin goes to the point (4,0,3). Determine the homogenous transformation matrix that will transform this line so that it is aligned with the y axis.

c A graphics scene is to be rotated about the line defined in part b in steps of 30^0. Find a homogenous transformation that will achieve this. (Sin(30) = 0.5, Cos(30) = 0.87).

e Given the following transformation matrix:

$$\begin{pmatrix} 0 & 0 & -1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Give a short geometric explanation of the four vectors making up the rows. Hence deduce what the transformation will do to a graphics scene

f A plane has Cartesian equation 5x + 3y -2z = 0. What is its equation after transformation of the scene using the matrix of part e.

The four parts carry equal marks.