# 2003 Paper 6 Question 5

## Computer Graphics and Image Processing

($a$) We use homogeneous coordinates to represent transformations in 3D space:

$$\begin{bmatrix} x'_H \\ y'_H \\ z'_H \\ w'_H \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & b_1 \\ a_{21} & a_{22} & a_{23} & b_2 \\ a_{31} & a_{32} & a_{33} & b_3 \\ c_1 & c_2 & c_3 & d \end{bmatrix} \begin{bmatrix} x_H \\ y_H \\ z_H \\ w_H \end{bmatrix}$$

($i$) Explain how to convert standard 3D coordinates, $(x, y, z)$, to homogeneous coordinates and how to convert homogeneous coordinates to standard 3D coordinates. [2 marks]

($ii$) Describe the types of transformations provided by each of the four blocks of coefficients in the matrix ($a_{11} \cdots a_{33}$, $b_1 \cdots b_3$, $c_1 \cdots c_3$, and $d$). [6 marks]

($iii$) Explain what transformation is produced by each of the following matrices:

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \qquad \begin{bmatrix} 1 & 0 & p & -p(1+r) \\ 0 & 1 & q & -q(1+r) \\ 0 & 0 & 1+r & -r(1+r) \\ 0 & 0 & 1 & -r \end{bmatrix}$$

[4 marks]

($b$) Describe an algorithm (in 2D) which clips an arbitrary polygon against an arbitrary axis-aligned rectangle. [8 marks]