Solution Notes - CGIP paper 6, 2003

(a)(i) $(x, y, z) \longrightarrow (x, y, z, 1)$

or $(x, y, z) \longrightarrow (xh, yh, zh, h)$

$$(x_H, y_H, z_H, w_H) \rightarrow \left(\frac{x_H}{w_H}, \frac{y_H}{w_H}, \frac{z_H}{w_H}\right)$$

(ii)[a] the 3×3 array $\begin{matrix} a_{11} \cdots a_{13} \\ \vdots \ddots \vdots \\ a_{31} \cdots a_{33} \end{matrix}$ performs affine transformations such as scaling, rotation, and shearing

[b] $b_1 \ldots b_3$ performs translations

[c] $c_1 \ldots c_3$ perform perspective transformations

[d] d is a global scaling factor

(iii) the first performs a perspective transformation, projecting about the origin onto the plane $z = 1$

the second does the same, projecting about the point (p, q, r) onto the plane $z = r + 1$

$$\begin{bmatrix} x'_H \\ y'_H \\ z'_H \\ w'_H \end{bmatrix} = \begin{bmatrix} 1 & 0 & p & -p(1+r) \\ 0 & 1 & q & -q(1+r) \\ 0 & 0 & 1+r & -r(1+r) \\ 0 & 0 & 1 & -r \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$$x' = \frac{x'_H}{w'_H} = \frac{x + pz - p - pr}{z - r} = \frac{x - p}{z - r} + p$$

$$z' = \frac{z'_H}{w'_H} = \frac{z + zr - r - r^2}{z - r} = 1 + r$$

(b) the algorithms given in lectures clip straight lines against rectangles or convex polygons against arbitrary polygons; it is the latter algorithm which is required.

Build the algorithm from a simpler algorithm which clips a polygon against an infinite edge. Clip the polygon against each edge in turn, passing the results of one stage to the next.

The algorithm [Sutherland-Hodgman polygon clipping] is described in 2 OHP slides in the notes [slides 99-100 in the 2000 notes], these should be reproduced with appropriate extra algorithmic material to ensure that the student has understood the material.

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MARKING SCHEME

(a)(i) $(x, y, z) \rightarrow (x, y, z, 1)$ or (xh, yh, zh, h) — 1
$(x_H, y_H, z_H, w_H) \rightarrow (x_H/w_H, y_H/w_H, z_H/w_H)$ — 1
— 2

(ii) [a] affine or scale + rotate + skew — 2
[b] translate — 1
[c] perspective — 2
[d] scale — 1
— 6

(iii) [first] perspective $tf =$ — 1
onto plane $z=1$ about origin — 1
[second] some idea of what's going on... — 1
onto plane $z=1+r$ about (p, q, r) — 1
— 4

— 12

(b) Sutherland-Hodgman algorithm*
re-entrant use of an infinite edge clipper — 2
correct description of the edge clipper — 2
correct identification of the four cases — 2
correct initialisation & termination — 1
getting it all together clearly & correctly — 1
— 8

— 20

*any other algorithm will be marked based on the correctness of the result and the clarity of the description and can obtain up to the full 8 marks

CGIP (Computer Graphics & Image Processing)
Overall Scheme for Exam Questions 2003

The course has four sections:

Background	3 lectures
2D Computer Graphics	4 lectures
3D Computer Graphics	5 lectures
Image Processing	3 lectures

These must all be tested in exam, preferably in proportion to the number of lectures given

Question	Slides in 2000 Notes	Marks Allocated BG	2D	3D	IP
p3 (a)	37 (29-38)	6			
(b)	269-271 (258-290)				6
(c)	78-84, 110-111		8		
p5 (a)	173-178 (161-179)			10	
(b)	17-26, 39-40	4			
(c)	246-250				6
p6 (a)	101-109, 124-133		1	11	
(b)	98-100		8		
		10	17	21	12

These questions give a good spread across the whole syllabus, test both algorithms and more general knowledge & require a student to understand at least two disparate parts of the course in order to get good marks on any of the questions.