ITC363 Sample Exam Solution & Marking Guide

Question 1

(a) i) The line segments of some edges cross.
ii) The extended lines through some edges cross, even though the line segments themselves do not cross.
iii) There are no intersections between any of the extended lines through edges.

Diagrams should be included that indicate this.

[3+3+3=9 marks]

(b) GL_TRIANGLE_FAN
The diagram will show a triangle fan, with lines fanning out to each vertex from the starting vertex.

[6 marks]

(c) A **triangle fan** can be used to triangulate regions near the poles. The first vertex should be at a pole with other vertices along a circle of constant latitude about the pole.
At other latitudes a **triangle strip** can be used to triangulate a region covering some small latitude difference for all longitudes. A pair of vertices is specified with the same longitude but different latitudes, and then this is repeated for each longitude about the sphere. The triangular strips are repeated to cover the region between the polar triangular fans.

[10 marks]

(d) The main advantage is that all transformations can be represented as matrices, which allows the matrices to be concatenated into a single matrix transformation, allowing efficient processing of multiple vertices in a graphics pipeline.

[5 marks]

Question 2

(a) To provide state values that are unchanged during the vertex processing of one or more primitives. The state values are sent from the client to the GPU between one invocation and another of the drawing (e.g. by glDrawArrays) of WebGL primitives. Examples of state values include: the colour for one or more primitives; parameters of transformation matrices to be applied to the vertices of one or more primitives; the transformation matrices themselves.

[10 marks]

(b)

i)

$$\mathrm{R}_z(\theta) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

[4 marks]

ii)

$$\mathrm{T}(d_x, d_y, d_z) = \begin{bmatrix} 1 & 0 & 0 & d_x \\ 0 & 1 & 0 & d_y \\ 0 & 0 & 1 & d_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

[4 marks]

iii) For a point: $\mathrm{T}(d_x, d_y, d_z)\begin{bmatrix} a \\ b \\ c \\ 1 \end{bmatrix} = \begin{bmatrix} a + d_x \\ b + d_y \\ c + d_z \\ 1 \end{bmatrix}$

For a vector: $\mathrm{T}(d_x, d_y, d_z)\begin{bmatrix} a \\ b \\ c \\ 0 \end{bmatrix} = \begin{bmatrix} a \\ b \\ c \\ 0 \end{bmatrix}$

The vector is unchanged by translation, the point is translated.

[4 marks]

(c) $Q_0 - P_0$ is the vector from a point on the plane to the off-plane point. The magnitude of the perpendicular distance from the plane to the off-plane point is the magnitude of the component of this vector, taken perpendicular to the plane. Since n is a unit vector in the required direction, that component is obtained as specified.

[8 marks]

Question 3

(a) A means of getting multiple copies of a model into a world at various locations in various sizes and at various orientations.

Scale (S) to desired size; Rotate (R) to desired orientation; Translate (T) to desired location: M = TRS.

[8 marks]

(b) Description includes:

- An origin for viewing coordinates is chosen, the view-reference point P_0.
- A look-at position is chosen, defining the viewing direction from eye to look-at positions. The z-axis is taken in the opposite direction ***n***.
- An up position is chosen in the upper half of the required vertical plane containing the z-axis. It defines a view-up vector ***V***.
- The horizontal (x) axis is the ***u*** = ***V*** x ***n*** /|**V** x ***n***|.
- The vertical (y) axis is ***v*** = ***n*** x ***u***.

[10 marks]

(c) i) A single point through which lines are drawn from all vertices.

ii) The lines drawn from vertices through the centre of projection.

iii) A plane perpendicular to the viewing direction and situated between the centre of projection and vertices in the view volume. The intersections of each projector with this plane is the projected point.

iv) The volume containing vertices that will not be clipped.

v) The planar surfaces of the view volume that are parallel to the projection plane (the nearest and the furthest from the viewer).

All shown on a labelled diagram.

[12 marks]

Question 4

(a) A-B: The order is A, $\alpha 2$, $\alpha 1$, B, $\alpha 3$, $\alpha 4$. The overlap of sections $\alpha 1$ to $\alpha 3$ with $\alpha 2$ to $\alpha 4$ is $\alpha 1$ to $\alpha 3$ that also lies within A to B is the section $\alpha 1$ to B. The line is clipped at $\alpha 1$.

C-D: The order is $\alpha 1$, C, $\alpha 2$, $\alpha 3$, D, $\alpha 4$. The overlap of sections $\alpha 1$ to $\alpha 3$ with $\alpha 2$ to $\alpha 4$ is $\alpha 1$ to $\alpha 3$ that also lies within C to D is the section $\alpha 2$ to $\alpha 3$. The line is clipped at $\alpha 2$ and $\alpha 3$.

[10 marks]

(b) i) object-space methods and image-space methods.

ii) image-space method

iii) In addition to the colour buffer for holding pixel values there is a z-buffer for holding the depth of the surface at the point corresponding to pixels. As polygons are rasterised, the depth corresponding to a candidate pixel is compared to any already stored, and the nearest is chosen.

[2+2+6=10 marks]

(c)

- **end-point interpolation**: The first and last control points are fitted.
- **affine invariance**: The Bezier curve of transformed control points is the same as the transformed Bezier curve.
- **convex hull property**: The curve is bounded by the convex hull of the control points.
- **linear precision**: A straight line is formed with appropriate control points.
- **variation diminishing**: The Bezier curve cannot fluctuate more than the control graph, the line joining the control points. That is, a straight line or plane cannot intersect the Bezier curve more than it intersects the control graph.

[10 marks]