NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2018-2019

CZ2003 COMPUTER GRAPHICS AND VISUALISATION

Apr/May 2019 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 5 pages.
2. Answer **ALL** questions.
3. This is a closed-book examination.
4. All questions carry equal marks.

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1. (a) Write parametric equation of a plane $x\,(u, v), y\,(u, v), z\,(u, v), u, v \in [0, 1]$ which passes through the point with Cartesian coordinates (1, 2, 3) while containing the straight line defined by

$$x = u - 1, \quad y = u + 2, \quad z = 2u - 1, \quad u \in (-\infty, \infty).$$

(5 marks)

(b) Define with functions $x\,(u, v), y\,(u, v), z(u, v), u, v \in [0, 1]$ the bilinear surface displayed in Figure Q1b and compute the Cartesian coordinates of the point with parametric coordinates (0.3, 0.3).

(8 marks)

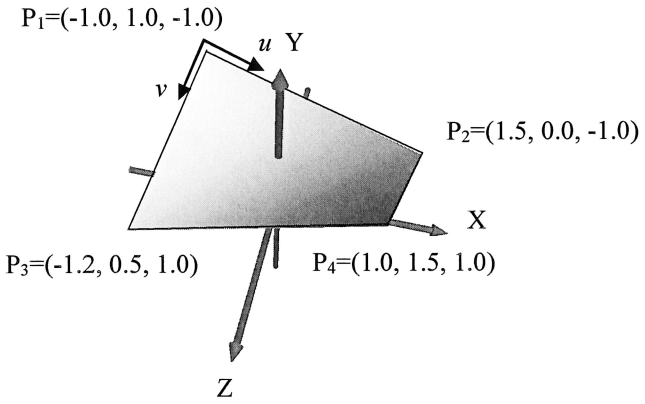


Figure Q1b

Note: Question No. 1 continues on Page 2

(c) Propose parametric functions $x(u, v)$, $y(u, v)$, $z(u, v)$, $u, v \in [0, 1]$ which will define the surface created by rotational (one counterclockwise rotation about axis Y) and translational (by 3 units in positive Y-direction) sweeping of the sinusoidal curve as shown in Figure Q1c.

(12 marks)

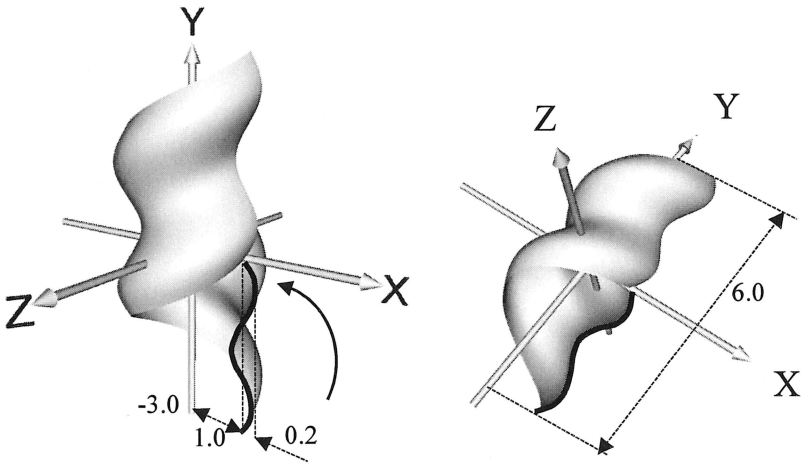


Figure Q1c

2. (a) Convert the implicit equation in Cartesian coordinates $1 - (x - 1)^2 - y^2 = 0$ to the equation in polar coordinates $r = r(\alpha)$.

(5 marks)

(b) Define by function $f(x, y) \geq 0$ the 2D object (shaded in black color) as displayed in Figure Q2b.

(8 marks)

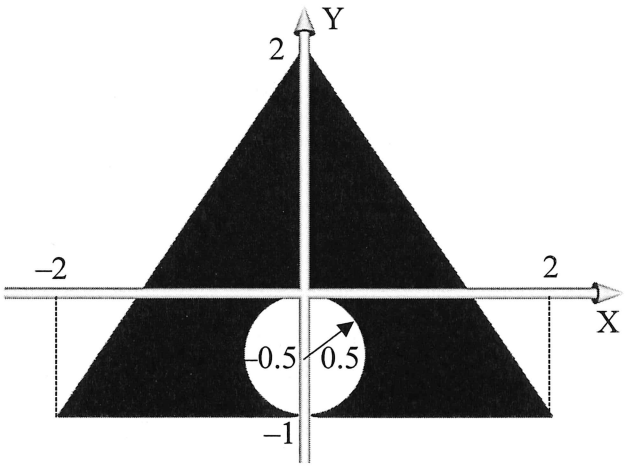


Figure Q2b

Note: Question No. 2 continues on Page 3

(c) Define parametrically with functions $x(u, v, w)$, $y(u, v, w)$, $z(u, v, w)$, $u, v, w \in [0, 1]$ the solid object displayed in Figure Q2c.

(12 marks)

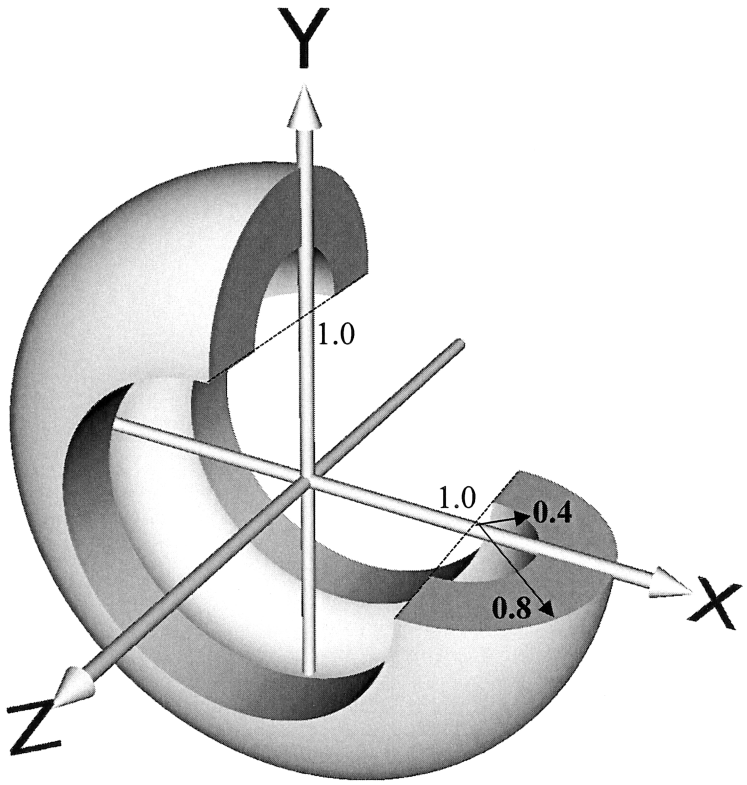


Figure Q2c

3. (a) Explain why homogeneous coordinates are used in 2D and 3D transformations.

(3 marks)

(b) Let **R** be a 2D rotation about the origin and **T** a 2D translation. Do **RT** and **TR** define the same composite transformation? Justify your answer mathematically.

(5 marks)

Note: Question Q3 continues on Page 4

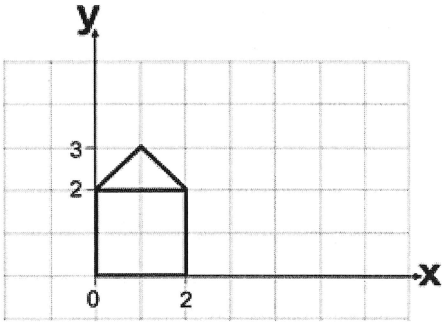
(c) Figure Q3c shows a 2D house model and a 2D affine transformation matrix **M**.

(i) Apply **M** to the house and sketch the transformed model. Label the coordinates of all vertices on your sketched figure.

(2 marks)

(ii) This matrix **M** represents a composition of several basic transformations. Write the matrix for each basic transformation and describe the order of these transformations. Note that translation, rotation, and scaling are basic transformations.

(6 marks)



$$\mathbf{M} = \begin{bmatrix} 0 & -0.5 & 0.5 \\ 2 & 0 & 2 \\ 0 & 0 & 1 \end{bmatrix}$$

Figure Q3c

(d) Write in a proper order the individual matrices that compose the reflection about a plane defined by $1 - x + y - z = 0$. The final matrix is not required.

(9 marks)

4. (a) Explain the following concepts.

(i) Texture mapping.

(2 marks)

(ii) Bump mapping.

(2 marks)

(iii) Displacement mapping.

(2 marks)

Note: Question Q4 continues on Page 5

(b) Suppose that a shiny plane $2x + 2y + 2z = 1$ is illuminated by a directional light source with lighting direction (0, 0, 1). If the viewer is at the origin, determine the position on this shiny plane at which the peak of the specular highlight occurs.

(10 marks)

(c) Propose a mathematical model that implements morphing which transforms a solid unit sphere centered at the origin into a solid cylinder parallel to the Z-axis with radius 2, center at the point (1, 1, 3) and height of 6. The morphing sequence has 200 frames and involves deceleration. The frame index starts at 1.

(9 marks)

END OF PAPER

CZ2003 COMPUTER GRAPHICS & VISUALISATION

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.