NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2019-2020

CZ2003 – COMPUTER GRAPHICS AND VISUALISATION

Nov/Dec 2019 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 6 pages.
2. Answer **ALL** questions.
3. This is a closed-book examination.
4. All questions carry equal marks.

---

1. (a) A plane is determined by two intersecting lines passing through points with XYZ Cartesian coordinates (1, 2, 3), (4, 5, 6) and (6, 5, 4), (1, 2, 3), respectively. Define this plane by parametric functions $x(u, v), y(u, v), z(u, v), u, v \in R$.

(5 marks)

(b) A curve displayed in Figure Q1b (left) is defined in polar coordinates r and α by the function $r = 1.2\sin(2\alpha - 0.5\pi)$, $\alpha \in [0,2\pi]$.

(i) Define this curve in the right-handed Cartesian coordinate system XY by parametric functions $x(u), y(u), u \in [0, 1]$.

(4 marks)

(ii) Based on the curve definition obtained in part (i), propose parametric functions $x(u, v), y(u, v), u, v \in [0, 1]$ defining the 2D shape located in the XY Cartesian coordinates system as it is displayed in Figure Q1b (right).

(4 marks)

Note: Figure Q1b continues on Page 2

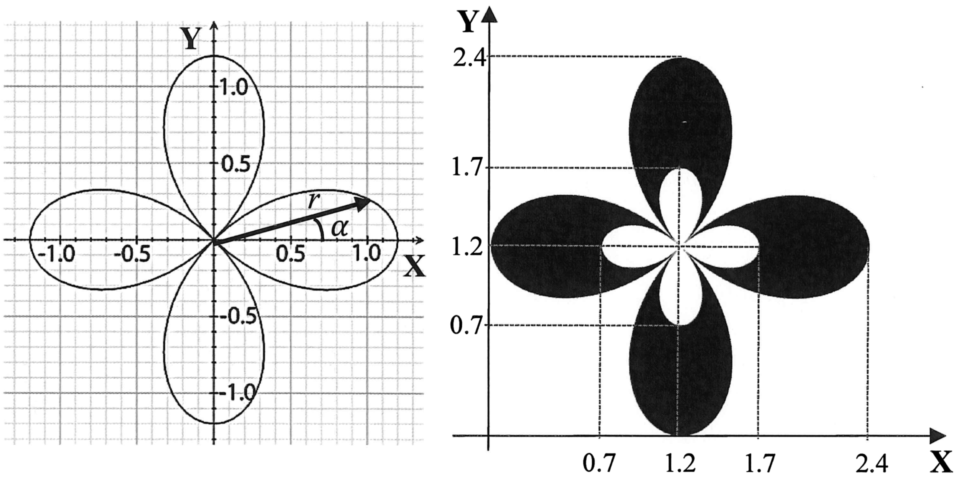

Figure Q1b

(c) Propose parametric functions $x(u), y(u), z(u)$, $u \in [0, 1]$ which will define the curve created by 40 revolutions with radius 0.4 while moving along the circle with radius 2.0 as shown in Figure Q1c. The curve starts at the positive axis Y and rotates counterclockwise till it reaches the positive axis X.

(12 marks)

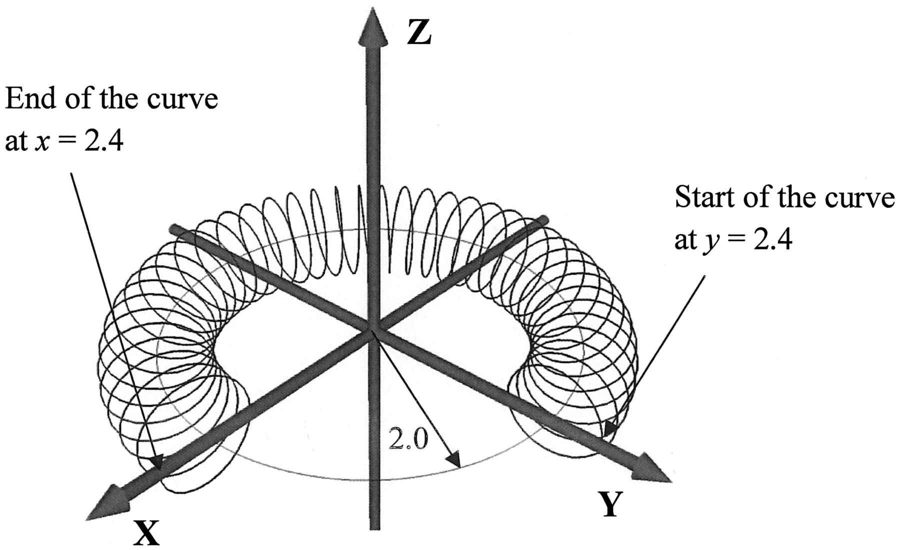

Figure Q1c

2. (a) Using the Cartesian coordinate system XY, write an explicit equation $y = f(x)$ of a straight line which passes through the point with coordinates (1, 2) and has 60° angle with the X axis.

(5 marks)

(b) The solid object displayed in Figure Q2b (front and back views) is constructed from a 3-sided pyramid with height 1 and a cylinder which has the height 2, the outer radius 0.5, and the inner radius 0.25.

(i) Define the pyramid and the cylinder by functions $f(x, y) \geq 0$.

(4 marks)

(ii) Based on the definition obtained in part (i), define the final solid object.

(4 marks)

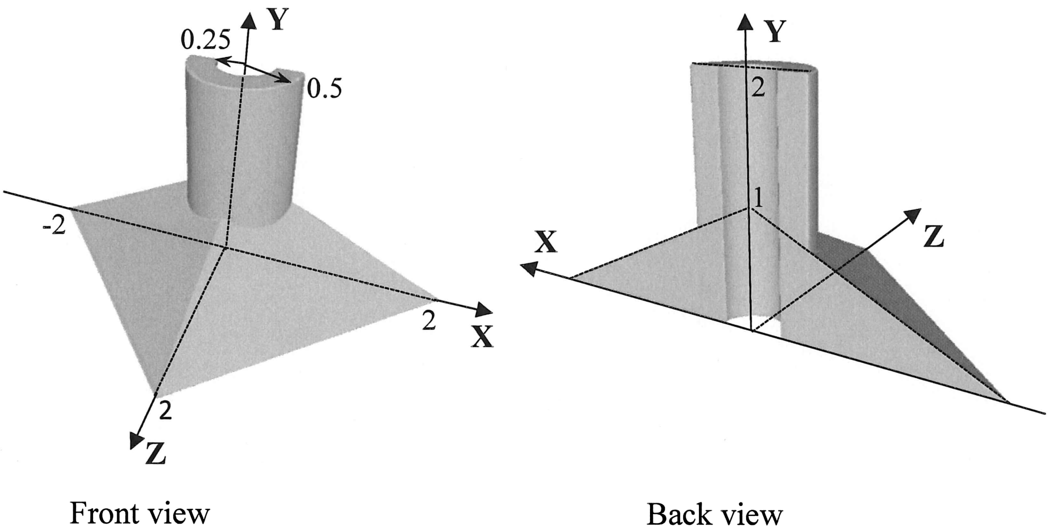

Figure Q2b

(c) With reference to Figure Q2c, propose parametric functions $x(u, v, w), y(u, v, w), z(u, v, w),\ u, v, w \in [0, 1]$ which will define the solid helical coil spring which has 4 revolutions done about axis X. The coil spring body has a round hollow channel inside it with the inner radius $r = 0.4$ while the outer radius $R = 0.8$. The distance from axis X to the centre of the spring is 2.0.

(12 marks)

Note: Figure Q2c continues on Page 4

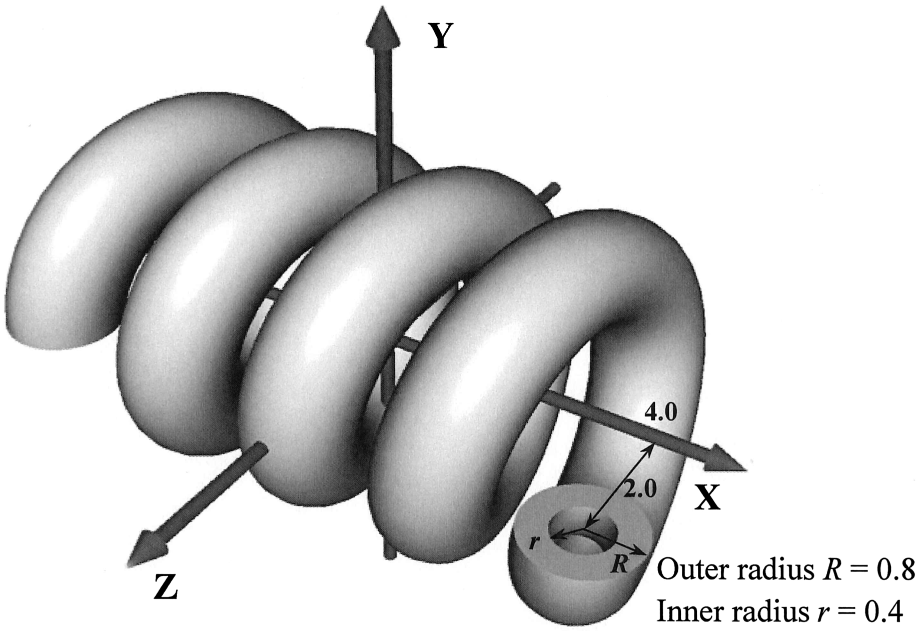

Figure Q2c

3. (a) Outline the main steps of the parametric texture mapping algorithm.

(5 marks)

(b) Derive a 3×3 matrix that defines the affine transformation mapping polygon $A_1A_2A_3A_4A_5$ to polygon $B_1B_2B_3B_4B_5$ as shown in Figure Q3.

(8 marks)

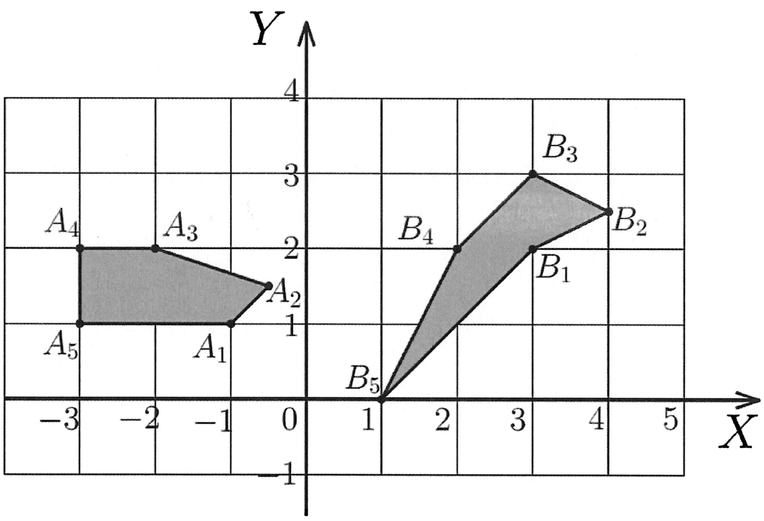

Figure Q3

Note: Question No. 3 continues on Page 5

(c) A triangle is formed by three vertices with coordinates (0, 10, 0), (10, 0, 0) and (10, 10, 0). It is rotated about an axis by angle 180°. The axis is defined by an initial point (50, -40, 30) and a terminal point (-100, 80, -60). Find the coordinates of the vertices of the rotated triangle.

(12 marks)

4. (a) One of two methods—texture mapping and displacement mapping—can be applied to a sphere with a chessboard image as the texture. Discuss the results generated by these two methods in terms of geometry and appearance.

(5 marks)

(b) Figure Q4 shows two shapes A and B. Using parametric equations, propose an animation model that transforms shape A into shape B. The animation consists of 100 frames and involves deceleration.

(8 marks)

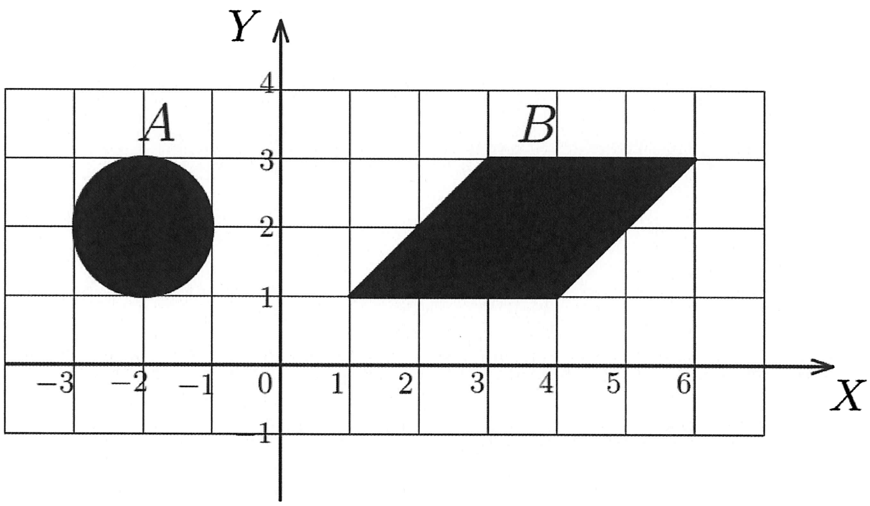

Figure Q4

(c) A point light source with intensity 1.0 is located at coordinates (0, 0, 20). It illuminates the cylinder defined by equation $y^2 + z^2 - 2z = 0$. An observer located at coordinates (27, 0, 11) is looking at the cylinder.

(i) Compute the lighting vector and viewing vector at $P = (0, 0, 2)$ on the cylinder.

(2 marks)

Note: Question No. 4 continues on Page 6

(ii) Assume that the diffuse coefficient of the cylinder is 0.4. Compute the diffuse reflection that the observer receives at $P = (0, 0, 2)$.

(3 marks)

(iii) Assume that the cylinder's specular coefficient and specular exponent are constant. Compute the coordinates of the point on the cylinder where the observer receives the maximum specular reflection.

(7 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.