# NANYANG TECHNOLOGICAL UNIVERSITY

## SEMESTER 1 EXAMINATION 2018-2019

## CZ2003 COMPUTER GRAPHICS AND VISUALISATION

Nov/Dec 2018 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 an implicit equation of a plane which passes through the point with Cartesian coordinates (1, 2, 3) while being orthogonal to the straight line defined by $x = u + 1$, $y = u - 2$, $z = 2u + 1$, $u \in (-\infty, \infty)$.

(5 marks)

(b) Write parametric equations $x(u, v)$, $y(u, v)$, $z(u, v)$, $u, v \in [0, 1]$ defining a triangular polygon which is bounded by the three segments defined by:

$x = 1 + 2u$ $y = 1 + u$ $z = 1 - u$ $u \in [0, 1]$
$x = 3 - u$ $y = 2 + u$ $z = 4u$ $u \in [0, 1]$
$x = 2 - u$ $y = 3 - 2u$ $z = 4 - 3u$ $u \in [0, 1]$.

(8 marks)

(c) Based on the way how polar coordinates are mapped to Cartesian, propose parametric functions $x(u)$, $y(u)$, $u \in [0, 1]$ which make the trigonometric sinusoidal curve (sine wave) follow a semicircle (half circle) with the radius of 0.75. The curve has to make 10 periodic oscillations (cycles) moving counterclockwise around the semicircle with the oscillations amplitude of $\pm 0.25$ as shown in Figure Q1.

(12 marks)

Note: Figure Q1 continues on Page 2

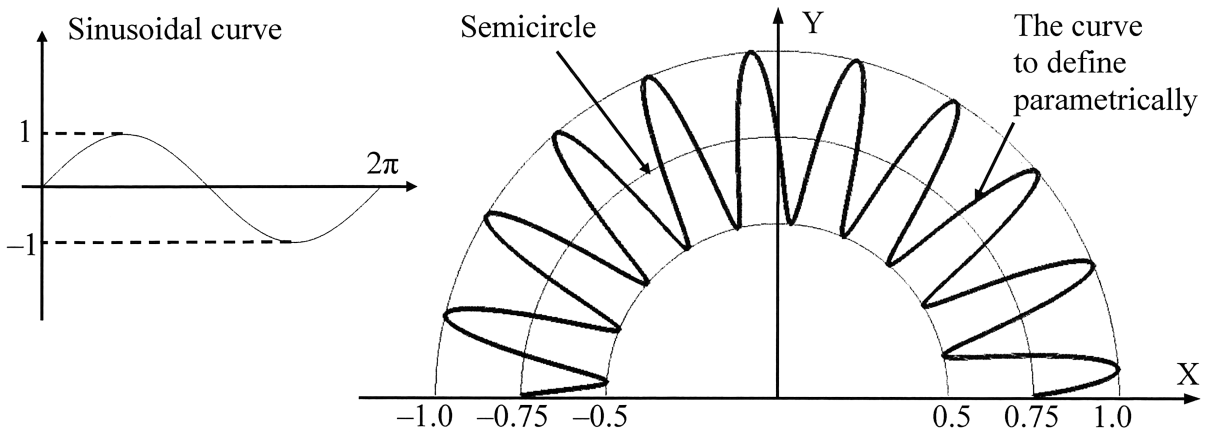


**Figure Q1**

2. (a) Write parametric equations $x(u, v, w)$, $y(u, v, w)$, $z(u, v, w)$, $u, v, w \in [0, 1]$ defining a solid ellipsoid with the centre at the point with coordinates (1, 2, 3) and the semi-axes of 4, 5 and 6.

(5 marks)

(b) (i) Define by function $f(x, y, z) \geq 0$ the solid object displayed in Figure Q2b. This is a four-sided solid pyramid with a half-cylindrical opening (radius of 0.25) at the bottom of it and a sphere (radius of 0.1) attached to the top.

(6 marks)

(ii) What are the coordinates of the centre and the size of the tight bounding box that has to be used for rendering of this object?

(2 marks)

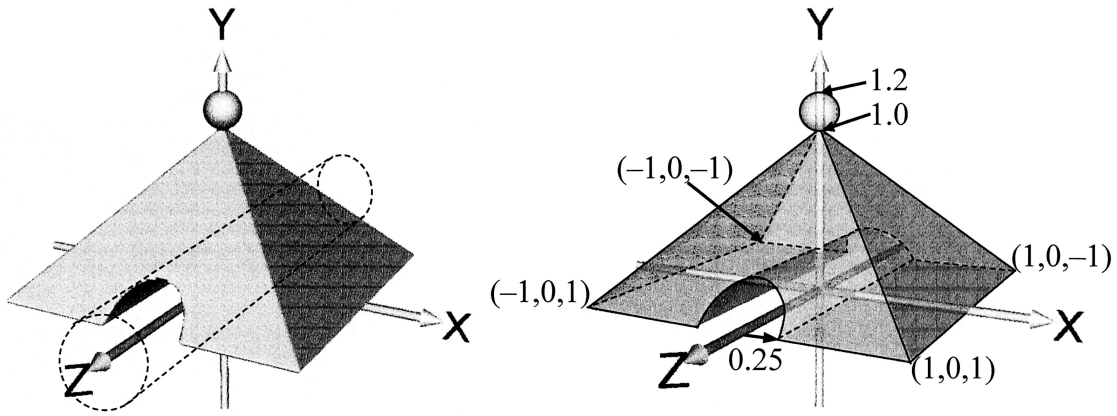


**Figure Q2b**

Note: Question 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. The object is created by rotational sweeping by $5\pi/4$ about axis Y of the sinusoidal curve followed by translational sweeping by 1.5 units parallel to axis Y.

(12 marks)

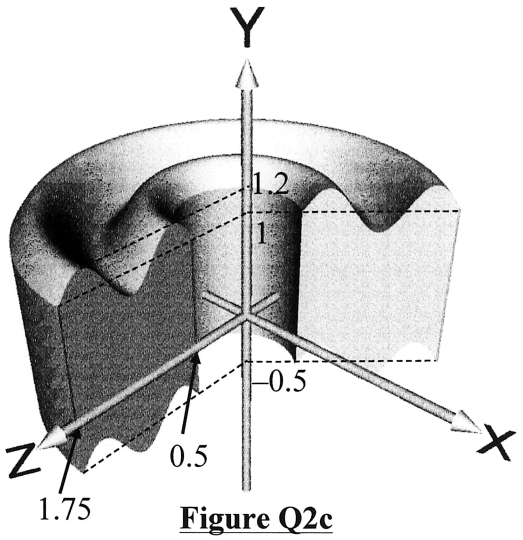


**Figure Q2c**

3. (a) A morphing model is given implicitly by $f(x, y) + (g(x, y) - f(x, y))t \geq 0$, with time parameter $t \in [0, 1]$. Using frame index $k$ as the parameter, revise this model such that the morphing consists of 120 frames starting from $k = 1$ and involves deceleration.

(5 marks)

(b) An ellipse defined by parametric equations: $x = 2\cos(2\pi u)$, $y = \sin(2\pi u)$, $z = 0$, $u \in [0, 1]$, undergoes a transformation, which is encoded by the following FVRML codes:

```
Transform {    scale          1  3  4
               translation    2  0  -1
               children [
        FShape { polygonizer "analytical_curve"
            geometry FGeometry {
               definition     "x=2*cos(2*u*pi); y=sin(2*u*pi); z=0;"
               parameters     [0  1]
               resolution     [100]    }
            appearance FAppearance { … }     }    ]    }
```

Derive a parametric representation $x(u)$, $y(u)$, $z(u)$, $u \in [0, 1]$ of the transformed ellipse.

(8 marks)

Note: Question 3 continues on Page 4

(c) With reference to Figure Q3, an affine transformation transforms the left polygon to the right polygon, part of which is removed in the image. Complete the right polygon by adding the missing vertices and find their coordinates.

(12 marks)

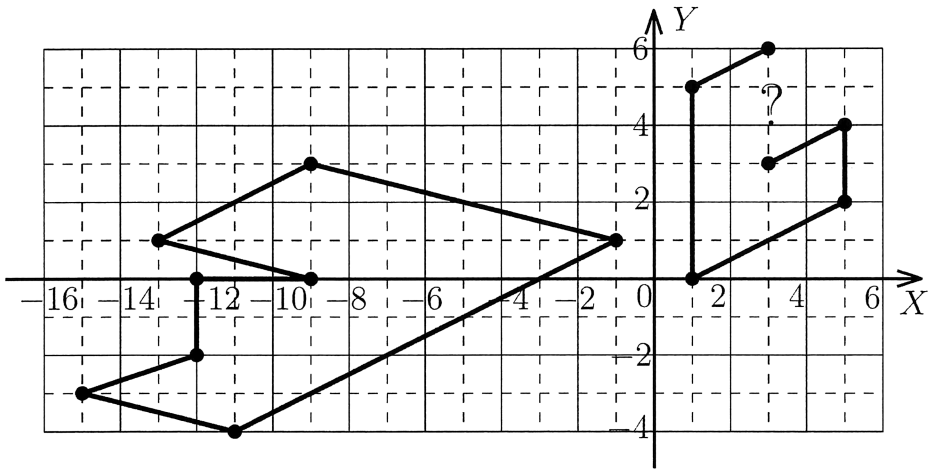


**Figure Q3**

4. (a) Compare a point light source and a directional light source in terms of the information required to define them.

(5 marks)

(b) With reference to Figure Q4, an image of size 351×143 is mapped to a cone defined by parametric equations:
$x = (90 - t)\cos(s)$, $y = (90 - t)\sin(s)$, $z = t$, $s \in [0, 2\pi]$, $t \in [0, 60]$.
Propose mapping functions from image pixel coordinates to the Cartesian coordinates of the cone surface that realize this texture mapping.

(8 marks)

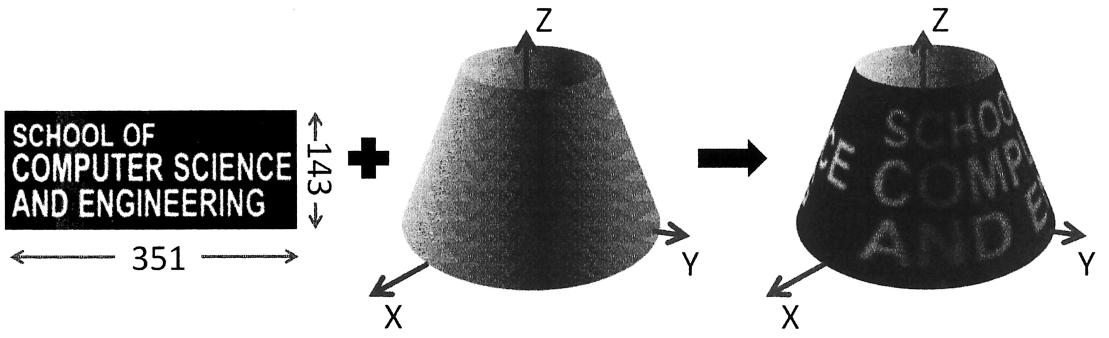


**Figure Q4**

Note: Question 4 continues on Page 5

(c) An origin-centred, axis-aligned cubical box with the edge length of 2 is illuminated by a point light source of intensity 0.6, which is located at the point with coordinates (0, 9, 13), and the ambient light source of intensity 0.2. The ambient reflection coefficient, diffuse reflection coefficient, specular reflection coefficient and specular parameter of the box are 0.4, 0.6, 0.5 and 2, respectively. An observer is located at the point with coordinates (–6, 0, 9).

(i) Using Phong illumination model, compute the reflected intensity received by the observer at the point with coordinates (0, 0, 1) which is located on the box.

(8 marks)

(ii) Compute the reflected intensity which the observer receives at the same point with coordinates (0, 0, 1) if the point light source is moved to the location with coordinates (0, 9, –20).

(4 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.