**CCG3013/N Computer Graphics**
**Final Exam Answer Script**
**September 2022**
**Set A**

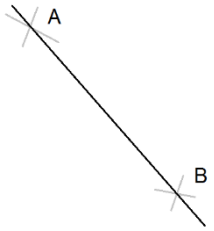
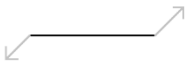
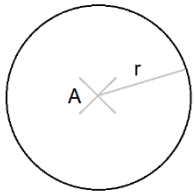
**Section A (60 marks)**

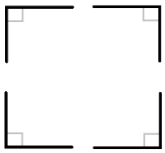
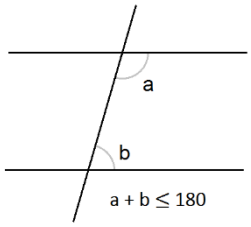
1) Name and discuss four applications of computer graphics. (12 marks)

| **Application** | **Discussion** |
|---|---|
| Augmented reality(AR) | It renders virtual environment and virtual objects with a given target image. |
| Virtual reality(VR) | It renders virtual environment and virtual objects using an immersive display equipment. |
| Data visualisation | It generates graphic objects to illustrate static and dynamic data. |
| Computer aided design(CAD) | It supports achitects, engineers, and artists to demonstrate the blueprints of products, in terms of look and feel at multiple perspectives. |
| Medical imagery | It captures either the interior and exterior of a human body, then it encodes the signal into images and videos. |

**1 mark** will be awarded for each correct application, maximum four only.
**2 marks** will be awarded for each correct corresponding discussion, maximum four only.

2) Explain and draw five Euclid's postulates. (15 marks)

| Euclid's postulates | Illustration |
|---|---|
| a. Given two points, it is possible to draw a right line. **(1 mark)** |  **(2 marks)** |
| b. The right line can be extended in both directions. **(1 mark)** |  **(2 marks)** |
| c. Given a center and a radius, we can draw a circle. **(1 mark)** |  **(2 marks)** |

| | |
|---|---|
| d. All right angles are equal. **(1 mark)** |  **(2 marks)** |
| e. Parallel postulate. **(1 mark)** |   **(2 marks)** |

3) Explain a unit form. Then, specify the two dimensional (2D) primitives and the corresponding quantities for a unit form in Figure 1 below. (10 marks)

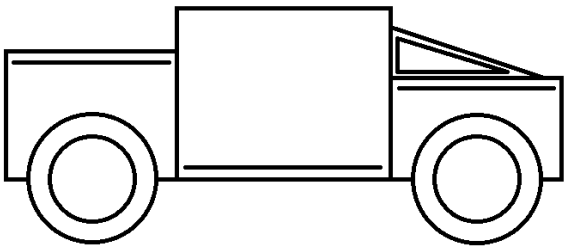


**Figure 1: Unit form**

It is a combination of simple objects that generate a more refined object. **(2 marks)**

| Shape | Quantity | Marks |
|---|---|---|
| Line | 3 | **(2 marks)** |
| Triangle | 2 | **(2 marks)** |
| Rectangular | 3 | **(2 marks)** |
| Circle | 4 | **(2 marks)** |

4) Given a three-dimensional (3D) original point, (x, y, z) at (15, 20, 25) in the 3D space. Compute the corresponding image point with the following transformations.
(a) Translate with a vector of (10, -20, -25), (4 marks)
(b) Rotate clockwise (CW) at 50 degrees along y-axis, (4 marks)
(c) Rotate counter-clockwise (CCW) at 78 degrees along z-axis, (4 marks)
(d) Scale with the factors of (2/5, 1/2, 4). (4 marks)

(a)

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$ (2 marks)

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 10 \\ 0 & 1 & 0 & -20 \\ 0 & 0 & 1 & -25 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 15 \\ 20 \\ 25 \\ 1 \end{bmatrix}$$ (1 mark)

$$= \begin{bmatrix} 25 \\ 0 \\ 0 \\ 1 \end{bmatrix}$$ (1 mark)

(b)

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 0 \end{bmatrix}$$ (2 marks)

$$= \begin{bmatrix} \cos(50) & 0 & \sin(50) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(50) & 0 & \cos(50) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 15 \\ 20 \\ 25 \\ 0 \end{bmatrix}$$ (1 mark)

$$= \begin{bmatrix} 15\cos(50) + 25\sin(50) \\ 20 \\ -15\sin(50) + 25\cos(50) \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} 28.79 \\ 20 \\ 4.58 \\ 0 \end{bmatrix}$$ (1 mark)

(c)

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 0 \end{bmatrix}$$ (2 marks)

$$= \begin{bmatrix} \cos(78) & -\sin(78) & 0 & 0 \\ \sin(78) & \cos(78) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 15 \\ 20 \\ 25 \\ 0 \end{bmatrix}$$ (1 mark)

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 15\cos(78) - 20\sin(78) \\ 15\sin(78) + 20\cos(78) \\ 25 \\ 0 \end{bmatrix}$$

$$= \begin{bmatrix} -16.44 \\ 18.83 \\ 25 \\ 0 \end{bmatrix} \text{ (1 mark)}$$

(d)

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} s_x & 0 & 0 & 0 \\ 0 & s_y & 0 & 0 \\ 0 & 0 & s_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} \text{ (2 marks)}$$

$$= \begin{bmatrix} 2/5 & 0 & 0 & 0 \\ 0 & 1/2 & 0 & 0 \\ 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 15 \\ 20 \\ 25 \\ 1 \end{bmatrix} \text{ (1 mark)}$$

$$= \begin{bmatrix} 6 \\ 10 \\ 100 \\ 1 \end{bmatrix} \text{ (1 mark)}$$

5) Briefly describe a digital video. Then, name and explain the two unique parameters of a digital video. (7 marks)

It is a series of images which is played over certain period of time. **(1 mark)**

| **Parameter** | **Explanation** |
|---|---|
| Frame **(1 mark)** | It is an image in a video that ordered with an index. **(2 marks)** |
| Frame rate **(1 mark)** | It is the number of images that flip in a second and measured in frame per second (fps). **(2 marks)** |

**Section B (10 marks)**

1) Evaluate and justify three suitable Disney's principles of animation for a water dam in energy generation. (10 marks)

| **Principle of animation** | **Justifications** |
|---|---|
| Arc **(1 mark)** | In the power generator, there is a fan with blades. **(1 mark)**<br>The water inflow will drive each tip of a blade that generates a circular arc, when it rotates. **(1 mark)** |
| Solid drawing **(1 mark)** | The fan in the power generator should be connected with a rotor through a shaft. **(1 mark)**<br>The fan, rotor, and shaft should be aligned at a center. **(1 mark)** |
| Slow in, slow out **(1 mark)** | When the velocity of the water inflow increases, the torque of the fan should be gradually increase. **(1 mark)**<br>When the velocity of the water inflow runs at a constant speed, the torque of the fan should be at constant too. **(1 mark)**<br>When the velocity of the water inflow decreases, the torque of the fan should be gradually decreases. **(1 mark)** |

**Section C (15 marks)**

1) Write a function in C++ OpenGL to get a position of a mouse input, (x, y) and to toggle the status of right mouse button. (15 marks)

```
void mouseControl(GLint button, GLint state, int x, int y){ (4 marks)
  y = window.height - y; (1 mark)
  switch(button){ (1 mark)
    case GLUT_RIGHT_BUTTON: (1 mark)
      if(state == GLUT_DOWN && (1 mark)
         !transform.rightMouseIsPressed){ (1 mark)
        transform.mouseX = x; (0.5 marks)
        transform.mouseY = y; (0.5 marks)
        transform.rightMouseIsPressed = true; (1 mark)
      }
      if(state == GLUT_UP && (1 mark)
         transform.rightMouseIsPressed){ (1 mark)
        transform.rightMouseIsPressed = false; (1 mark)
      }
    break; (1 mark)
  }
}
```

**Section D (15 marks)**

Write a render function in C++ OpenGL to scale a 100 units' radius sphere with a step radius increases by 2%, then stop the animation when the radius reached 200 units. (15 marks)

```
GLfloat radius = 100; (1 mark)
GLfloat stepRadius = 2; (1 mark)
void render(){ (1 mark)
  glPushMatrix(); ((1 mark)
  glFrontFace(GL_CW); (1 mark)
    if(radius < 200){ (1 mark)
      radius = radius*stepRadius; (2 marks)
    }
    glutSolidSphere(radius, 24, 24); (3 marks)
  glFrontFace(GL_CCW); (1 mark)
  glPopMatrix(); (1 mark)
  glutSwapBuffers(); (1 mark)
  glutPostRedisplay(); (1 mark)
}
```

1.02

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