NATIONAL UNIVERSITY OF SINGAPORE

CS3241 — COMPUTER GRAPHICS

(AY2019/2020 SEMESTER 1)

MIDTERM ASSESSMENT

Time Allowed: **1 Hour 30 Minutes**

INSTRUCTIONS

1. This is an **OPEN BOOK** assessment.

2. This question paper comprises **TEN (10)** printed pages, including this page.

3. You are also provided with **one OCR Form** to write your answers.

4. Clearly **write** and **shade** your **STUDENT NUMBER** in **SECTION B** of your **OCR Form** using a **2B PENCIL**.

5. You do not need to write in **SECTION A** of your OCR Form.

6. There are **25** multiple-choice questions. Each question has one correct answer. **2 marks** are awarded for each correct answer and there is no penalty for a wrong answer.

7. The full score is **50 marks**.

8. Answer **ALL** questions.

9. Use only a **2B PENCIL** to **shade** your answers on your **OCR Form**.

10. **Submit only the OCR Form**.

(1) How much framebuffer memory is required for a 400×300 window, with 32-bit color (i.e. for RGBA), 24-bit depth value and using **single-buffering**?

A. $400 \times 300 \times (32 + 24)$ bytes
B. $400 \times 300 \times (32 + 24) \times 2$ bytes
C. $400 \times 300 \times (4 + 3)$ bytes
D. $400 \times 300 \times (4 \times 2 + 3)$ bytes
E. $400 \times 300 \times (4 + 3) \times 2$ bytes

(2) How much framebuffer memory is required for a 400×300 window, with 32-bit color (i.e. for RGBA), 24-bit depth value and using **double-buffering**?

A. $400 \times 300 \times (32 + 24)$ bytes
B. $400 \times 300 \times (32 + 24) \times 2$ bytes
C. $400 \times 300 \times (4 + 3)$ bytes
D. $400 \times 300 \times (4 \times 2 + 3)$ bytes
E. $400 \times 300 \times (4 + 3) \times 2$ bytes

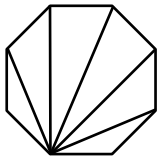
(3) Suppose we have 3 pieces of glass filters of equal thickness, of which one is **cyan** color, one is **magenta**, and one is **yellow**. We want to shine a beam of white light through the glass filters to produce **red light**. Which is/are the glass filter(s) that we should shine the white light through?

A. Cyan only.
B. Cyan and magenta.
C. Magenta and yellow.
D. Yellow and Cyan.
E. Cyan, magenta and yellow.

(4) We are given a **cube** that is modelled using the minimum number of triangles. Suppose we want to draw the cube using the `GL_TRIANGLES` OpenGL primitive mode, how many times do we need to call the `glVertex*()` function?

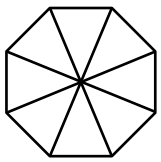
A. 8
B. 18
C. 24
D. 36
E. 72

(5) An octagon is modelled using a set of triangles as shown in the diagram on the right. Suppose we want to draw the octagon using the `GL_TRIANGLE_FAN` OpenGL primitive mode, how many times do we need to call the `glVertex*()` function?



A. 6
B. 7
C. 8
D. 9
E. 18

(6) An octagon is modelled using a set of triangles as shown in the diagram on the right. Suppose we want to draw the octagon using the `GL_TRIANGLE_FAN` OpenGL primitive mode, how many times do we need to call the `glVertex*()` function?



A. 7
B. 8
C. 9
D. 10
E. 24

(7) In the rendering pipeline, in what coordinate space are the vertices when they arrive at the **primitive assembly** stage?

A. World space
B. View space
C. Clip space
D. NDC space
E. Window space

(8) In the rendering pipeline, in what coordinate space are the vertices when they arrive at the **rasterization** stage?

A. World space
B. View space
C. Clip space
D. NDC space
E. Window space

(9) If we render a **cube** (which has 6 faces) using **perspective projection**, what is the minimum possible number of faces that can be eliminated by **back-face culling**?

A. 4
B. 3
C. 2
D. 1
E. 0

(10) If a polygon is eliminated by **back-face culling**, which of the following statements is/are true?

i. The polygon will not go through the clipping operation.
ii. The polygon will not be rasterized.
iii. The polygon may still appear in the final image if it is not occluded.

A. None of them.
B. All (i), (ii) and (iii).
C. Only (i) and (ii).
D. Only (ii) and (iii).
E. Only (ii).

(11) A **fragment** generated by the rasterizer may not appear in the final rendered image. Which of the following is/are possible reason(s)?

i. The fragment has been discarded by z-buffer hidden surface removal.
ii. The fragment has been discarded by clipping.
iii. The fragment has been overwritten by a fragment from a later triangle.

A. Only (i).
B. Only (iii).
C. All (i), (ii) and (iii).
D. Only (i) and (ii).
E. Only (i) and (iii).

(12) Which of the following statements is/are true about the **z-buffer algorithm**?

i. Depth testing of a fragment is done during rasterization.
ii. z-buffer algorithm fails if polygons overlap each other cyclically.
iii. z-buffer algorithm cannot be used with OpenGL orthographic projection.
iv. When z-buffer is used, polygons must be rendered in back-to-front order.

A. None of them.
B. Only (i).
C. Only (ii) and (iv).
D. Only (iii).
E. Only (i) and (iii).

(13) In the z-buffer, a value of 0 represents the depth at the near plane, and 1 at the far plane. After the z-buffer is cleared, polygons are being rendered one-by-one. Which of the following statements correctly describes the possible evolution of the z-buffer value at a certain pixel location?

A. The z-value can increase and decrease randomly.
B. The z-value can only increase in value.
C. The z-value can only decrease in value.
D. The z-value can only increase until 1 and then decrease.
E. The z-value can only decrease until 0 and then increase.

(14) You are at the foot of a tall vertical building, trying to take a photo of the front face of the building. You want to minimize perspective distortion in the picture (want to avoid having the top of the building appearing much smaller than the lower part of the building). What should you do?

A. Use a camera with high megapixels.
B. Use a wide-angle lens.
C. Use a telephoto lens.
D. Tilt your camera up to point at the middle of the building.
E. Orientate your camera so that its image plane is parallel to the front face of the building.

(15) Which of the followings is the matrix that rotates objects about the point (5, 3, 4), where the rotation axis is parallel to and in the same direction as the *z*-axis, and the rotation angle is θ?

A. $\mathbf{T}(-5, -3, 0) \cdot \mathbf{R}_z(\theta) \cdot \mathbf{T}(5, 3, 0)$
B. $\mathbf{T}(5, 3, 0) \cdot \mathbf{R}_z(\theta) \cdot \mathbf{T}(-5, -3, 0)$
C. $\mathbf{T}(0, 0, 4) \cdot \mathbf{R}_z(\theta) \cdot \mathbf{T}(0, 0, -4)$
D. $\mathbf{T}(0, 0, -4) \cdot \mathbf{R}_z(\theta) \cdot \mathbf{T}(0, 0, 4)$
E. None of the above.

(16) Which of the following statements is true?

A. The up-vector passed to the `gluLookAt()` function must always be perpendicular to the view direction.
B. The projection plane in OpenGL must always be perpendicular to the *z*-axis of the camera coordinate frame.
C. The view transformation matrix transforms the object coordinate frame to coincide with the camera coordinate frame.
D. View transformation is performed after projection.
E. None of the above.

(17) A vertex, whose camera coordinates are (0.5, 0.5, −1), is being projected using the following OpenGL orthographic projection:

```
glOrtho( -1, 1, -1, 1, 0, 1 );
```

What will be the vertex's Normalized Device Coordinates (NDC)?

A. (0.5, 0.5, 1)
B. (0.5, 0.5, 0)
C. (0.5, 0.5, −1)
D. (–0.5, –0.5, 0)
E. (–0.5, –0.5, 1)

(18) A rectangle has vertices ***A***: (–3, 0, –15), ***B***: (12, 0, –15), ***C***: (12, 6, –15), ***D***: (–3, 6, –15) in the camera space. Given that the near and far plane distances must be set as 5 and 30 respectively, which of the following `glFrustum` function calls correctly sets up a view frustum that maximizes the image size of the rectangle (the entire rectangle exactly fills the viewport)?

A. `glFrustum( -1, 4, 0, 2, 5, 30 );`
B. `glFrustum( -1, 4, 0, 2, -5, -30);`
C. `glFrustum( -3, 12, 0, 6, 5, 30);`
D. `glFrustum( -3, 12, 0, 6, -5, -30 );`
E. `glFrustum( -1.5, 6, 0, 3, 5, 30 );`

(19) In the following code, which transformations are actually applied to vertex `v`?

```
glMatrixMode( GL_MODELVIEW );
glLoadMatrixd( A );
glPushMatrix();
    glMultMatrixd( B );
    glPushMatrix();
        glMultMatrixd( C );
    glPopMatrix();
    glPushMatrix();
        glMultMatrixd( D );
        glPushMatrix();
            glMultMatrixd( E );
            glBegin( GL_POINTS ); glVertex3fv( v ); glEnd();
        glPopMatrix();
    glPopMatrix();
    glMultMatrixd( F );
glPopMatrix();
glMultMatrixd( G );
```

A. `FGv`
B. `ABDEv`
C. `EDBAv`
D. `ABCDEv`
E. `EDCBAv`

(20) What does the homogeneous coordinates $[6\ \ 4\ \ 2\ \ 2]^T + [2\ \ 4\ \ 6\ \ 0]^T$ represent?

A. The 3D vector (4, 4, 4).
B. The 3D vector (5, 6, 7).
C. The 3D point (5, 6, 7).
D. The 3D point (4, 4, 4).
E. The 3D point (8, 8, 8).

(21) Which of the following is equivalent to this `gluLookAt()` function call:

```
gluLookAt( ex, ey, ez, ex+2, ey, ez, 1, 1, 0 );
```

A. `glRotated(90, 0, 0, 1); glTranslated(-ex, -ey, -ez);`
B. `glTranslated(-ex, -ey, -ez); glRotated(90, 0, 1, 0);`
C. `glRotated(90, 0, 1, 0); glTranslated(-ex, -ey, -ez);`
D. `glTranslated(-ex, -ey, -ez); glRotated(90, 1, 1, 0);`
E. `glRotated(90, 1, 1, 0); glTranslated(-ex, -ey, -ez);`

(22) Which of the following method(s) can *reduce* **z-fighting**?

i. Increase the number of bits to store each z-buffer value.
ii. Move the viewing volume's near plane further from the camera.
iii. Break the polygons into many small triangles.

A. Only (i) and (ii).
B. Only (i) and (iii).
C. Only (i).
D. Only (ii).
E. All (i), (ii) and (iii).

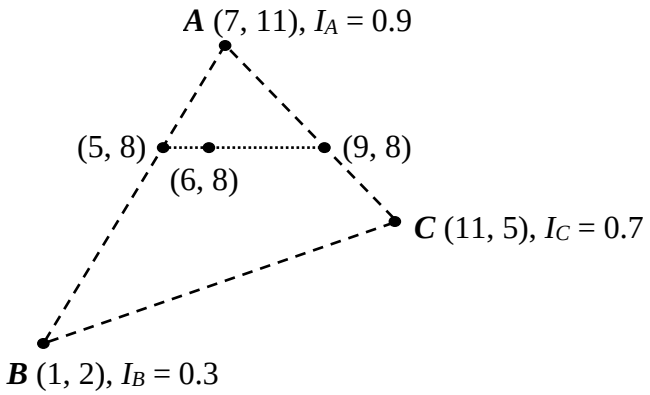
(23) A line segment from the pixel location (4, 7) to (54, 107) is scan-converted. Assuming the line segment is drawn as thin as possible and not broken, what is the number of fragments (pixels that are turned on) that are produced for this line segment? This number includes the two fragments at the two end points of the line segment.

A. 50
B. 51
C. 100
D. 101
E. 112

(24) A curve of $y = x^2 / 100$ is scan-converted from the pixel location (0, 0) to (200, 400). Assuming the curve is drawn as thin as possible and not broken, what is the number of fragments (pixels that are turned on) that are produced for this curve? This number includes the two fragments at the two end points of the curve.

A. 600
B. 602
C. 201
D. 401
E. 426

(25) Given the following triangle whose vertices ***A***, ***B***, ***C*** are at *pixel locations* (7, 11), (1, 2), and (11, 5) respectively, and the **intensity** attribute values at the vertices are 0.9, 0.3, 0.7 respectively. What is the intensity value at the pixel location (6, 8) assuming the triangle is rasterized with smooth shading?



A. 0.650
B. 0.700
C. 0.725
D. 0.750
E. 0.800

——— END OF QUESTIONS ———

(scratch paper)

(scratch paper)