北京郵電大學

Queen Mary University of London

For examiners' use only

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Total	

EBU5405 A

Joint Programme Examinations 2018/19

EBU5405 3D Graphics Programming Tools

Paper A

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number										
BUPT student number										
Class number										

NOT allowed: electronic calculators and electronic dictionaries.

INSTRUCTIONS

1. **You must NOT take answer books, used or unused, from the examination room.**
2. Write only with a black or blue pen **and in English**.
3. Do all rough work in the answer book – **do not tear out any pages**.
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. **Read the instructions on the inside cover.**

Examiners

Dr Marie-Luce Bourguet, Dr Atm Shafiul Alam

Instructions

Before the start of the examination

1) Place your BUPT and QM student cards on the corner of your desk so that your picture is visible.

2) Put all bags, coats and other belongings at the back/front of the room. All small items in your pockets, including wallets, mobile phones and other electronic devices must be **placed in your bag in advance**. **Possession of mobile phones, electronic devices and unauthorised materials is an offence.**

3) Please ensure your mobile phone is switched off and that no alarm will sound during the exam. **A mobile phone causing a disruption is also an assessment offence.**

4) Do not turn over your question paper or begin writing until told to do.

During the examination

1) You must not communicate with or copy from another student.

2) If you require any assistance or wish to leave the examination room for any reason, please raise your hand to attract the attention of the invigilator.

3) If you finish the examination early you may leave, but not in the first 30 minutes or the last 10 minutes.

4) For 2 hour examinations you may **not** leave temporarily.

5) For examinations longer than 2 hours you **may** leave temporarily but not in the first 2 hours or the last 30 minutes.

At the end of the examination

1) You must stop writing immediately – **if you continue writing after being told to stop, that is an assessment offence.**

2) Remain in your seat until you are told you may leave.

Question 1

a) The following questions refer to 3D graphics programming and its applications.

[7 marks]

i) Rendering a 3D scene needs the representation of three types of objects. What are they?

(3 marks)

ii) Briefly discuss the usage of 3D Graphics for medical visualisation applications.

(4 marks)

	Do not write in this column
	7 marks

b) The following questions refer to the 3D rendering pipeline.

[8 marks]

i) Which rendering steps are affected by the camera settings? Explain your answer.

(5 marks)

ii) What is the final step of the pipeline. What are the natures of its inputs and outputs?

(3 marks)

	Do not write in this column
	8 marks

c) Consider the OpenGL code shown in **Code box 1**. In this code, find the statements that are respectively responsible for:

[10 marks]

i) Registering a callback function.

(2 marks)

ii) Setting the window background colour state.

(2 marks)

iii) Forcing buffered OpenGL commands to be executed.

(2 marks)

iv) Setting the viewing volume.

(2 marks)

v) Resetting the current transformation matrix.

(2 marks)

```
void myInit(void) {
   glClearColor(0.0, 0.0, 0.0, 0.0);
   glColor3f(1.0, 1.0, 1.0);
   glMatrixMode(GL_PROJECTION);
   glLoadIdentity();
   gluOrtho2D(0.0, 640.0, 0.0, 480.0);
}

void mydisplay(){
   GLint vertices[3][2] = {{20, 10}, {74, 74}, {129, 83}};
   glClear(GL_COLOR_BUFFER_BIT);
   glBegin(GL_POINTS);
   glVertex2iv(vertices[0]);
   glVertex2iv(vertices[1]);
   glVertex2iv(vertices[2]);
   glEnd();
   glFlush();
}

int main(int argc, char** argv){
   glutInit(&argc, argv);
   glutInitWindowSize(640, 480);
   glutCreateWindow("Window");
   glutDisplayFunc(mydisplay);
   myInit();
   glutMainLoop();
}
```

Code box 1

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	10 marks

Question marking: $\frac{}{7} + \frac{}{8} + \frac{}{10} = \frac{}{25}$

Question 2

a) This question is about geometric modelling using polygonal approximation of surfaces, i.e. a polygon mesh.

[8 marks]

i) When declaring a polygon mesh, polygon orientations (windings) should be consistent, e.g. all counter clockwise. Explain why this statement is correct.

(4 marks)

ii) Explain how the Euler's formula allows a polygon mesh to be made of three types of list only. What are they?

(4 marks)

	Do not write in this column
	8 marks

b) Consider a cube with its centre at point P_f (x_f, y_f, z_f) and its sides aligned with the axes.

[10 marks]

i) You want to rotate the cube by an angle Θ about the z-axis and about its centre P_f. Demonstrate that the resulting transformation can be represented by the 4×4 matrix M shown in **Figure 1**. Show your calculations.

(7 marks)

ii) You now want to rotate the cube about an arbitrary axis. Without showing the full angle calculations, explain how the resulting transformation matrix can be calculated.

(3 marks)

$$M = \begin{pmatrix} \cos\Theta & -\sin\Theta & 0 & x_f - x_f\cos\Theta + y_f\sin\Theta \\ \sin\Theta & \cos\Theta & 0 & y_f - x_f\sin\Theta - y_f\cos\Theta \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Figure 1

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		10 marks

c) This question is about viewing transformations. Consider the two figures shown in **Figure 2** below. Derive the parameters of the gluLookAt function (you can replace all z coordinates with a random value).

[7 marks]

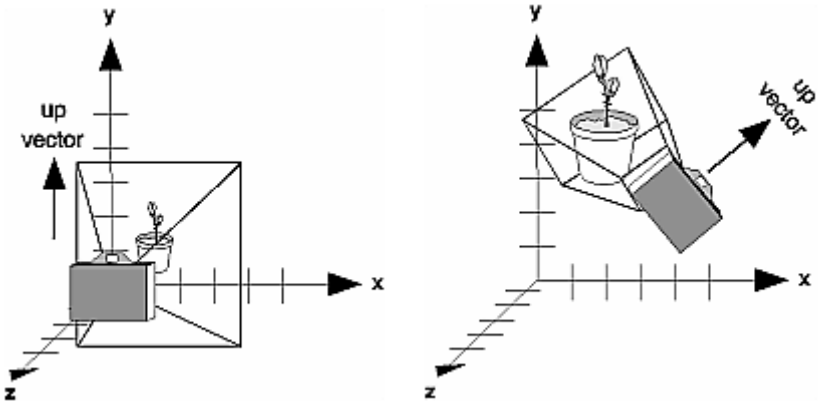

Figure 2

	Do not write in this column
	7 marks

Question marking: $\frac{}{8} + \frac{}{10} + \frac{}{7} = \frac{}{25}$

Question 3

a) Answer the multiple-choice questions below by entering your choice (A, B, C or D) in the dedicated space (the small square that appears immediately on the right of each question). For each question, make only one choice.

[10 marks]

	Do not write in this column
Q1: A light source positioned infinitely away from the objects it illuminates is: A. a spotlight source. B. a point light source. C. a parallel light source. D. a surface light source.	
Q2: A surface which shows a small highlight is: A. very bright. B. quite bright. C. neither bright or dull. D. not bright at all.	
Q3: What is the main purpose of setting an ambient light source in a scene? A. to simulate sun light. B. to simulate indirect illumination. C. to simulate night lighting conditions. D. to simulate interaction between light sources.	
Q4: Why are normal to the surfaces needed for lighting calculations? A. to calculate the amount of diffuse reflection. B. to calculate the direction of diffuse reflection. C. to calculate the amount of ambient reflection. D. to calculate the direction of ambient highlight.	
Q5: What kind of reflection does the Lambert's cosine law follow? A. specular reflection. B. diffuse reflection. C. mirror reflection. D. ambient reflection.	
	10 marks

b) The following questions refer to lighting.

[15 marks]

i) Describe the properties of the light source (type and colour) that has been declared in **Code box 2**. Explain your answer.

(4 marks)

ii) What needs to be changed in the code of **Code box 2** to modify the type of the light source (not its colour)? Explain your answer.

(3 marks)

iii) What properties should a surface material have to appear bright, unsaturated blue and with a large white highlight, when it is illuminated with the light source declared in **Code box 2**? Explain your answer.

(8 marks)

```
GL float ambientLight[] = {0.3, 0.3, 0.3, 1.0};
GL float diffuseLight[] = {0.7, 0.7, 0.7, 1.0};
GL float specularLight[] = {1.0, 1.0, 1.0, 1.0};
GlLightfv(GL_LIGHT0, GL_AMBIENT, ambientLight);
GlLightfv(GL_LIGHT0, GL_DIFFUSE, diffuseLight);
glEnable(GL_LIGHT0);
GLfloat lightPos[] = {-50.0, 50.0, 100.0, 1.0};
glLightfv(GL_LIGHT0, GL_POSITION, lighPos);
```

Code box 2

	Do not write in this column
	15 marks

Question marking: $\frac{}{10} + \frac{}{15} = \frac{}{25}$

Question 4

a) Answer the multiple-choice questions below by entering your choice (A, B, C or D) in the dedicated space (the small square that appears immediately on the right of each question). For each question, make only one choice.

[10 marks]

	Do not write in this column
Q1: Perspective projection: A. allows for accurate measurements. B. appears realistic. C. preserves parallel lines. D. includes isometric projection.	
Q2: What is the effect of perspective foreshortening? A. Objects close to the camera appear small. B. Objects away from the camera appear small. C. Objects close to the camera are distorted. D. Objects do not get distorted.	
Q3: Perspective projections include: A. cavalier projection. B. oblique projection. C. axonometric projection. D. one-point projection.	
Q4: In OpenGL, perspective projection can be requested using the following function: A. glOrtho. B. gluLookAt. C. glFrustum. D. gluNewQuadric.	
Q5: In OpenGL, isometric projection can be requested using the following function: A. glOrtho. B. glFrustum. C. gluPerspective. D. glScale.	
	10 marks

b) The following questions refer to rasterisation.

[10 marks]

i) Explain how edge equations are used for polygon rasterisation.

(5 marks)

ii) Discuss the problem of pixels that are exactly on an edge when rasterising a random polygon.

(5 marks)

	Do not write in this column
	10 marks

c) Consider a polygon mesh that is made of random polygons, including concave ones. What would you do to ensure that rasterisation will be both correct and quick?

[5 marks]

	Do not write in this column
	5 marks

Question marking: $\frac{}{10} + \frac{}{10} + \frac{}{5} = \frac{}{25}$

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