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 2016/17

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 in 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 Yizhe Song

Filename: 1617_EBU5405_A No answerbook required

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) Name the 3D Graphics rendering steps that correspond to the following descriptions:

[6 marks]

i) Transform 3D coordinates into 2D screen coordinate system.

(2 marks)

ii) Draw pixels.

(2 marks)

iii) Remove primitives outside camera's view.

(2 marks)

	Do not write in this column
	6 marks

b) This question is about the 3D Graphics rendering pipeline.

[10 marks]

i) Why is the 3D Graphics rendering pipeline said to be "like a manufacturing assembly line"?

(3 marks)

ii) How many of the rendering steps in the pipeline are related to the virtual camera? What are they?

(4 marks)

iii) Which rendering steps are sharing the same OpenGL transformation functions? Why?

(3 marks)

	Do not write in this column
	10 marks

c) This question is about OpenGL.

[9 marks]

i) OpenGL is made of three libraries. What are they and what are their differences?

(7 marks)

ii) Explain the role of the "Display callback" function in an OpenGL program.

(2 marks)

	Do not write in this column
	9 marks

Question marking: $\frac{}{6} + \frac{}{10} + \frac{}{9} = \frac{}{25}$

Question 2

a) This question is about geometric modelling. Consider the polygon mesh shown in Figure 1.

[10 marks]

i) Two different types of polygon are used in the mesh of Figure 1. What are they?

(2 marks)

ii) Describe the advantages and disadvantages of each type of polygon you identified in the previous question.

(4 marks)

iii) What would you modify in the mesh of Figure 1 to obtain a better approximation of the shape of a human head?

(2 marks)

iv) What would you modify in the mesh of Figure 1 to make rendering faster?

(2 marks)

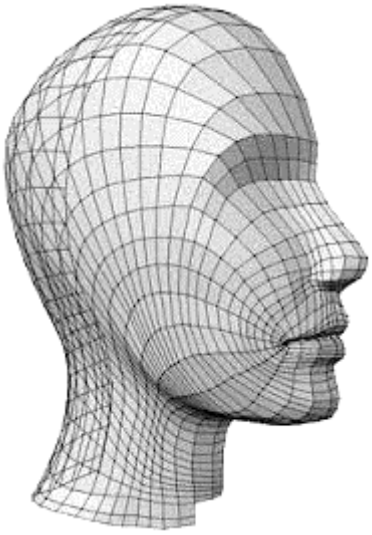

Figure 1

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	10 marks

b) This question is about modelling transformations. Consider the image shown in Figure 2. It shows three objects: the sun, the earth and the moon. To simplify the movement of the objects, let's assume that: (1) the earth is moving around the sun on a circular trajectory which is centred on the sun, (2) the earth is tilted by 23 degrees in the XY plane and rotating on itself, and (3) the moon is rotating around the earth on a circular trajectory which is centred on the earth.

[15 marks]

i) Starting from one model of a sphere, how many modelling transformations must be applied to each object, in order to achieve the animation described above? Describe these transformations.

(10 marks)

ii) Is the scene shown in Figure 2 an example of linear or hierarchical modelling? Justify your answer.

(5 marks)

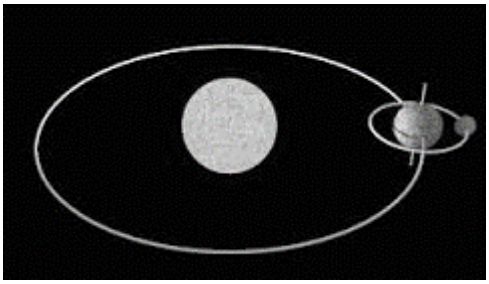

Figure 2

	Do not write in this column
	15 marks

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

Question 3

a) This question is about the Phong lighting model used in OpenGL.

[10 marks]

i) Why is the Phong model said to be empirical?

(1 mark)

ii) What is "indirect illumination" and how is it implemented in the Phong model?

(5 marks)

iii) Using the Phong model, how do you make an object look very shiny?

(4 marks)

	Do not write in this column
	10 marks

b) This question is about lighting calculations in OpenGL. Calculate and describe the appearance (colour and shininess) of an object illuminated under the conditions declared in Code box 1.

[7 marks]

```
float light_ambient[] = {0.5, 0.0, 0.0, 1.0};
float light_diffuse[] = {0.0, 1.0, 0.0, 1.0};
float light_specular[] = {0.5, 0.5, 0.5, 1.0};
float material_ambient[] = {0.5, 0.5, 0.5, 1.0};
float material_diffuse[] = {1.0, 0.0, 0.0, 1.0};
float material_specular[] = {1.0, 1.0, 1.0, 1.0};
float shininess = 100.0;
```

Code box 1

	Do not write in this column
	7 marks

c) This question is about projection. Consider the code shown in Code box 2.

[8 marks]

i) Identify all the lines in the code that are related to projection. Comment on their roles.

(4 marks)

ii) Modify the code so the projection becomes orthogonal and the object appears small in the centre of the window.

(4 marks)

```
void myInit(){
   glutInitWindowSize(500, 500);
   glMatrixMode(GL_PROJECTION);
   glLoadIdentity();
   glFrustum(-0.25,0.25,-0.25,0.25,0.2,2.0);
}

void mydisplay(){
    glMatrixMode(GL_MODELVIEW);
    glLoadIdentity();
    gluLookAt(1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0);
    glClear(GL_COLOR_BUFFER_BIT);
    glutWireCube(1.0);
    glFlush();
}
```

Code box 2

	Do not write in this column

	8 marks

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

Question 4

a) This question is about the OpenGL camera. Figure 3 shows the viewing transformation matrix. **[12 marks]**

i) The viewing transformation matrix shown in Figure 3 is the result of combining three rotations and one translation. Do you agree with this statement? Justify your answer. **(5 marks)**

ii) Which OpenGL function can be used to generate a viewing transformation matrix? What are its arguments and how are they used to generate the viewing transformation matrix? **(7 marks)**

$$\begin{bmatrix} \hat{r} & -\hat{r}\cdot\overline{eye} \\ \hat{u} & -\hat{u}\cdot\overline{eye} \\ -\hat{l} & \hat{l}\cdot\overline{eye} \\ 0\ \ 0\ \ 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} x' \\ y' \\ z' \end{bmatrix}$$

Figure 3

	Do not write in this column
	12 marks

b) This question is about rasterisation.

[13 marks]

i) What is rasterisation?

(2 marks)

ii) Concave polygons are often triangulated before rasterisation. Why?

(4 marks)

iii) Consider the images shown in Figure 4. Which of these triangulation results (a, b, or c) is of the best quality? Justify your answer.

(4 marks)

iv) Give two rasterisation techniques commonly used on triangles.

(3 marks)

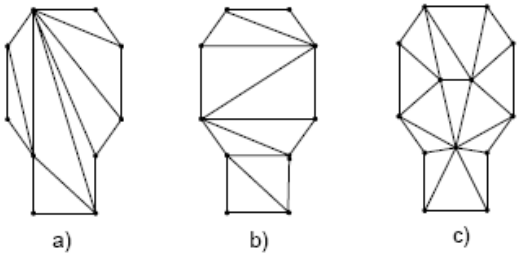

Figure 4

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		13 marks

Question marking: $\frac{}{12} + \frac{}{13} = \frac{}{25}$

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