

UNIVERSITY COLLEGE DUBLIN  
Faculty of Science

AUG 2005

COMP 3003 (Visual Computing - Graphics)

Instructor: Hamish Carr

Duration: 105 minutes

No aids allowed

This examination paper consists of **13** pages and **12** questions. Please bring any discrepancy to the attention of an invigilator. The number in brackets at the start of each question is the number of points the question is worth.

Answer all questions marked **MANDATORY** and 4 questions marked **CHOICE**. Since the exam has a total of **70** marks, you should spend approximately 1.5 minutes per mark.

For instructor's use only:

	Score
1 (7)	
2 (7)	
3 (7)	
4 (7)	
5 (7)	
6 (7)	
Subtotal	

	Score
7 (7)	
8 (7)	
9 (7)	
10 (7)	
11 (7)	
12 (7)	
Subtotal	

Total (70)	
------------	--

## 1. Coordinate Systems (MANDATORY: 7 marks total)

(a) [3] What are the standard coordinate systems used to process geometry and how are they related to each other?

(b) [4] Give the homogeneous transformation matrices for the following:

i. Rotation by 60 degrees clockwise around the Z-axis.

ii. Translation by the vector  $[1, -3, 5]$ .

iii. Rotation around the point  $[2, 0, 1]$ .

iv. Scaling by a factor of 21 in the y dimension.

## 2. Perspective Projection (MANDATORY: 7 marks total)

(a) [1] What is *foreshortening*?

(b) [2] Show an example of *3-point projection*.

(c) [4] Assume that you are standing at the origin, looking down the positive  $x$  axis with an image plane at a distance  $d$  in front of you. Show how to construct the perspective projection matrix that maps vertices in world coordinates to the image plane.

## 3. The OpenGL (Projective) Pipeline (MANDATORY: 7 marks total)

(a) [1] At what stage of the OpenGL pipeline are matrix transformations applied?

(b) [1] What is the difference between a *pixel* and a *fragment*?

(c) [1] What is *OpenGL state*?

(d) [4] Give OpenGL code for drawing a yellow circle of a given radius.

```
void drawCube(int radius)
    { /* drawCube() */
```

```
    } /* drawCube() */
```

## 4. Animation (MANDATORY: 7 marks total)

(a) [2] How do OpenGL's matrix stacks help animate characters?

(b) [5] Sketch a suitable animation hierarchy for a human hand.

5. Colour, Lighting and Shading (MANDATORY: 7 marks total)

(a) [2] What is the *Phong lighting model*?

(b) [2] Why is the RGB model of colour used in computer graphics?

(c) [2] How do you compute the angle between two vectors for lighting calculations?

(d) [1] What optimization does OpenGL perform on this calculation by default?

## 6. Textures (MANDATORY: 7 marks total)

(a) [2] Give the parametric equation for the line passing through the points  $(0, 1)$  and  $(-3, 14)$ .

(b) [1] What is a *texture*?

(c) [1] Why do we use textures in graphics?

(d) [1] How are parametric surfaces used for texturing?

(e) [1] How do you apply shading to a textured surface?

(f) [1] Why do we need interpolation for texturing?

## 7. GUIs and GLUT (CHOICE: 7 marks total)

(a) [2] What is an *event*?

(b) [1] What is *GLUT*?

(c) [2] How does GLUT implement event processing?

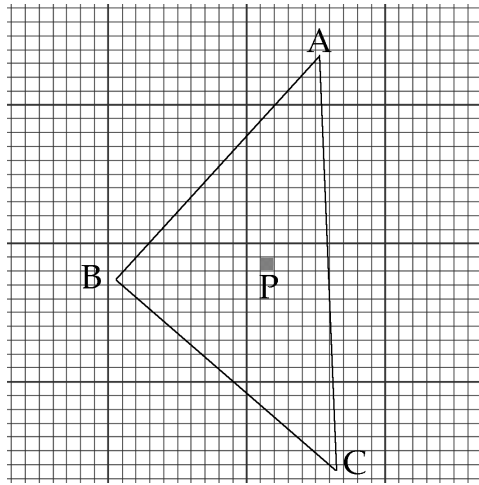
(d) [1] What *widgets* are available in GLUT?

(e) [1] What was the first commercially available GUI?

## 8. Rasterization and Interpolation (CHOICE: 7 marks total)

(a) [2] What is the difference between *Phong shading* and *Gouraud shading*?

(b) [2] Assume that point P in the picture below is pure magenta, i.e.  $(R, G, B) = (255, 0, 255)$ . What does that tell you about the colours at A, B, and C?



(c) [3] What are *barycentric coordinates* and how can they be used for interpolation?

## 9. Blending &amp; Compositing (CHOICE: 7 marks total)

(a) [3] What is the *frame buffer* and what is it used for?

(b) [3] What fragment tests does OpenGL perform on each pixel?

(c) [1] How does *fog* affect an image?

10. Optimization (CHOICE: 7 marks total)

(a) [2] What are the basic mechanisms for *optimizing* rendering?

(b) [2] What is the difference between transform rate and fill rate? Which is more important for textured objects?

(c) [3] What is a *display list* and how does it optimize rendering?

## 11. I/O Devices (CHOICE: 7 marks total)

(a) [3] What is a *sensor* and how does it work? Give three examples of sensors.

(b) [2] What is the difference between *additive* and *subtractive* output devices?

(c) [2] What is the *gamut* of a device?

12. Image Analysis (CHOICE: 7 marks total)

(a) [2] What is the difference between *computer graphics* and *image analysis*?

(b) [2] Describe how to compute a histogram for a grey-scale image.

(c) [3] Give a filter mask for *blurring* an image.

**End of examination**

**Total pages: 13**

**Total marks: 70**