

Given Name:_____ Family Name:_____

Student Number:_____ Signature:_____

UNIVERSITY COLLEGE DUBLIN
Faculty of Science

COMP 3003 (Visual Computing - Graphics)
Instructor: Hamish Carr

Sample Exam Paper
December 2004

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

(a) [2] What are *homogeneous coordinates*?

(b) [2] Show how to convert 3-D *homogeneous coordinates* to 3-D *cartesian coordinates*.

(c) [3] Vertices in coordinate system B can be converted to coordinate system A by matrix multiplication in homogeneous coordinates. Let B be defined by basis vectors $(1, 2, 2, 1)_A$, $(-4, 1, 1, 1)_A$, and $(0, 3, -3, 1)_A$ with origin of $(2, -3, 4, 1)_A$. Give the homogeneous matrix for converting vertices from coordinate system A to coordinate system B.

2. Perspective Projection (MANDATORY: 7 marks total)

(a) [1] What is a *vanishing point*?

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

(c) [5] Assume that you are standing at the origin, looking down the z-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) [3] What matrices does OpenGL keep track of for you, and what do they do?

(b) [4] Give OpenGL code for drawing an unshaded untextured red cube centred at the origin. You may make your cube any size and orientation that is convenient to you. You may not use `glutSolidCube()` or `glutWireCube()`.

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

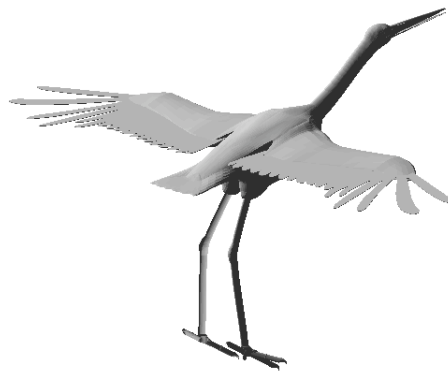
```
    } /* drawCube() */
```

4. Animation (MANDATORY: 7 marks total)

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

(b) [1] How do OpenGL's matrix stacks help animate characters?

(c) [5] For the model shown of a stork, sketch a suitable bone hierarchy for animating it.



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

(a) [3] What is the *Phong lighting model*?

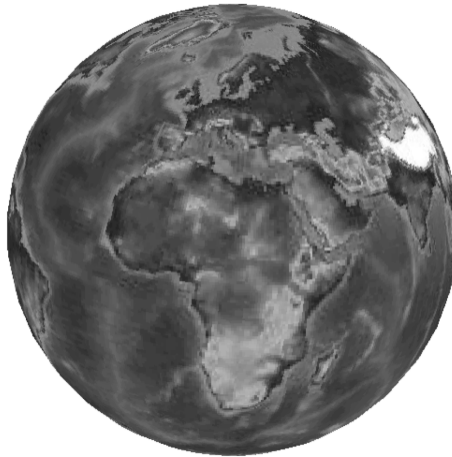
(b) [3] Describe how the surface normal vector is used for lighting calculations.

(c) [1] Give RGB coordinates for the colour yellow. (Hint: where is yellow in the rainbow?)

6. Textures (MANDATORY: 7 marks total)

(a) [3] What is the difference between the implicit, explicit and parametric forms of a line? Give examples.

(b) [4] The image of the world shown below has been drawn with no lighting, but with a texture on the surface of the earth. Assume that all of the relevant code will be in a single function: what additional OpenGL code is required so that the textured world is properly shaded assuming that the sun is the light source?



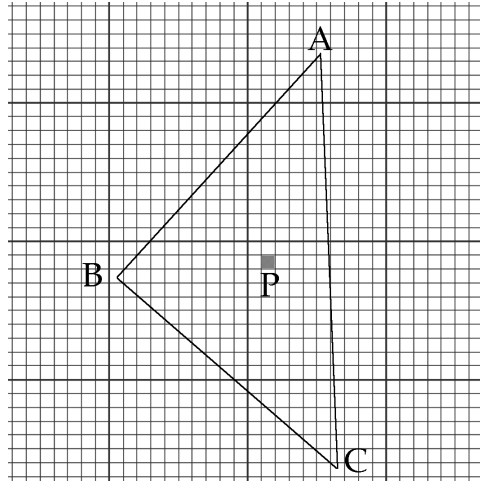
7. GUIs and GLUT (CHOICE: 7 marks total)

(a) [2] What is the *event loop*?

(b) [5] Give code for a simple GLUT program that accepts keyboard input and renders an image. You need not handle mouse input or handle any OpenGL functionality: i.e. you do not have to set matrices, lights, vertices, &c. You should restrict yourself to setting up a window, setting appropriate functions, and setting the program running.

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

(a) [4] To fill in the triangle shown, explain how to determine which pixels should be set.



(b) [3] Assume that point A in the picture above is red, point B is blue and point C is green. Explain how to compute the colour of pixel P.

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

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

(b) [4] Describe how to draw translucent objects in OpenGL.

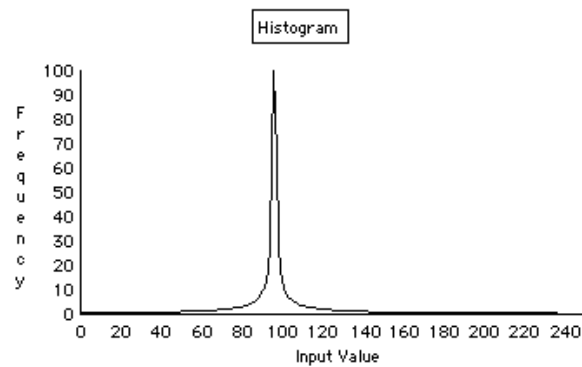
10. Optimization (CHOICE: 7 marks total)

- (a) [2] What is the difference between transform rate and fill rate? Which is more important for textured objects?
- (b) [3] Describe three ways of increasing the number of triangles your OpenGL card can render in a given amount of time.
- (c) [2] What is the difference between *clipping* and *culling*?

11. Image Analysis (CHOICE: 7 marks total)

(a) [3] What is a *filter mask* and how is it applied to an image. Show a small example.

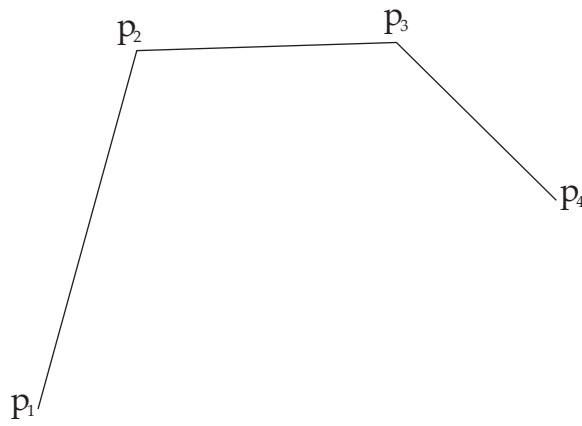
(b) [4] Suppose that you have the following histogram distribution. Sketch a suitable transfer function to improve the contrast in the image.



12. Curves and Surfaces (CHOICE: 7 marks total)

(a) [2] What is C^1 continuity and why is it important?

(b) [5] In the following image, use the de Casteljau algorithm to find the points on the Bzier curve at parameter values of $t = 0.25$, $t = 0.5$ and $t = 0.75$. Sketch the Bzier curve that passes through these points.



End of examination

Total pages: 13

Total marks: 70