UNIVERSITY COLLEGE DUBLIN
Faculty of Science

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] For a given object, what does each of the following matrices do to the object?

   i. $A = \begin{bmatrix} 0.707 & 0 & 0.707 & 0 \\ 0 & 1 & 0 & 0 \\ -0.707 & 0 & 0.707 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

   ii. $B = \begin{bmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & -1 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

   iii. $C = AB$

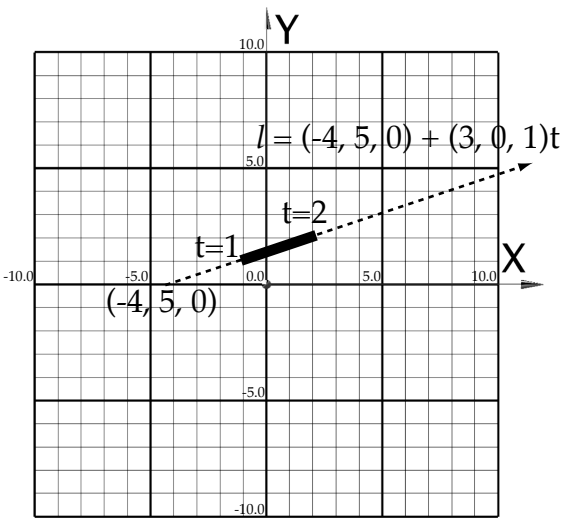
   iv. $D = BAB^{-1}$

2. Perspective Projection (MANDATORY: 7 marks total)

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

   (b) [1] What is an *orthogonal projection*?

   (c) [5] Assume that your eye is at the origin looking down the z-axis with an image plane at a distance $d = 1$ in front of you. In front of you is the wall shown on the left-hand diagram. The wall is 5 feet high, so the top of the wall lies along the line $\vec{l} = (-4, 5, 0) + (3, 0, 1)\,t$, as shown, with the ends of the wall at $t = 1$ and $t = 2$, respectively.



World

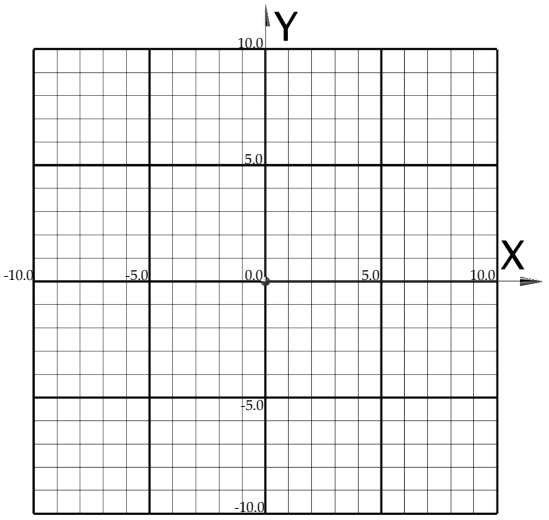


Image Plane

   i. On the grid marked "image plane", draw the top of the wall *accurately*. You may assume that all of the simplifications discussed in class have been applied.

   ii. Draw the bottom of the wall *accurately*. (Hint: it is at eye level).

   iii. What are the coordinates in the image plane of the vanishing point?

   iv. Locate the ends of the wall along the top of the wall in the image plane, and drop perpendicular lines to the ground. Shade in the wall.

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

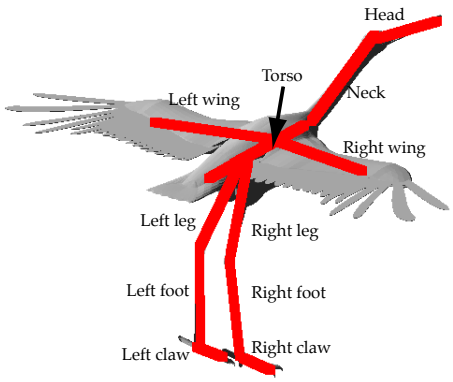
   (a) [4] Sketch the stages of the OpenGL pipeline and briefly explain what each one does.

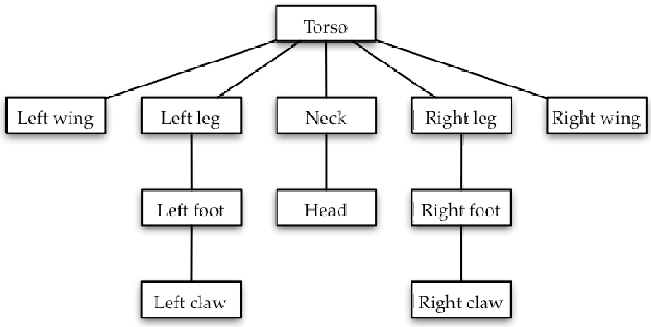
   (b) [3] What matrices does OpenGL keep track of for you, and what do they do?

4. Animation (MANDATORY: 7 marks total)

   (a) [2] What is a *joint*?

   (b) [5] You are given the model of a stork with the transformation hierarchy shown below. Give OpenGL code for drawing this in a given animation pose. You may assume that two functions are predefined: SetBonePose() and DrawBone(). SetBonePose("Head") will apply the appropriate transformation for drawing the head, while DrawBone("Head") will draw the head, and so on.





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

   (a) [2] What is *Gouraud shading* and how is it computed?

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

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

6. Textures (MANDATORY: 7 marks total)

   (a) [2] Give implicit, explicit and parametric forms for the circle in 2-D with radius 1 centred at the origin.

   (b) [1] Give an example of a parametric coordinate system on a sphere.

   (c) [2] Suppose that you wished to paint a texture on the walls of a cylinder, but not on the ends. How would you compute texture coordinates for points on walls of the cylinder?

   (d) [1] What is the difference between GL_CLAMP and GL_REPEAT?

   (e) [1] What is the difference between GL_REPLACE and GL_MODULATE?

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

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

   (b) [2] What is a *callback*?

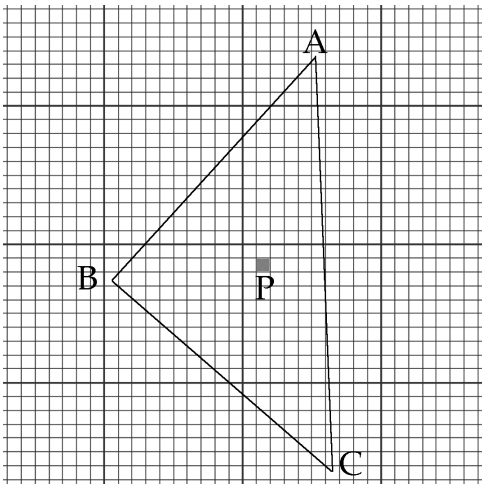
   (c) [2] What is a *widget*?

   (d) [1] What is your favourite GUI and why?

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

   (a) [3] How do we use bilinear interpolation in computing the colour of a pixel?

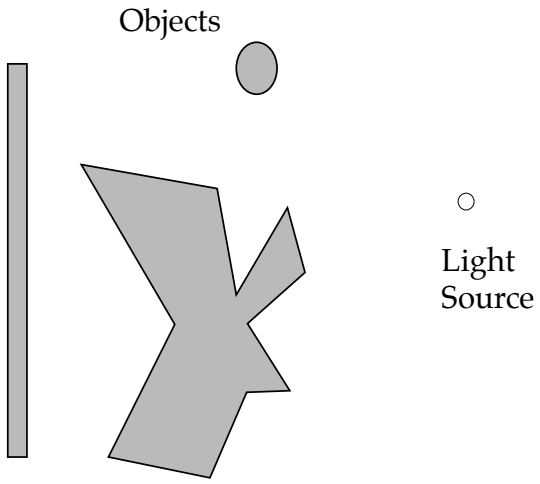
   (b) [4] Assume that point A in the picture below is red, point B is blue and point C is green. Explain how to compute the colour of pixel P.



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

   (a) [1] How does OpenGL support stereo images?

   (b) [3] What is a *shadow*? On the diagram below, show which regions are shadowed.



   (c) [3] What is *aliasing*? Give two ways to reduce it.

10. Optimization (CHOICE: 7 marks total)

(a) [2] What is *texture caching*? Explain how to use it in OpenGL.

(b) [2] What is the difference between *immediate mode* and *retained mode*?

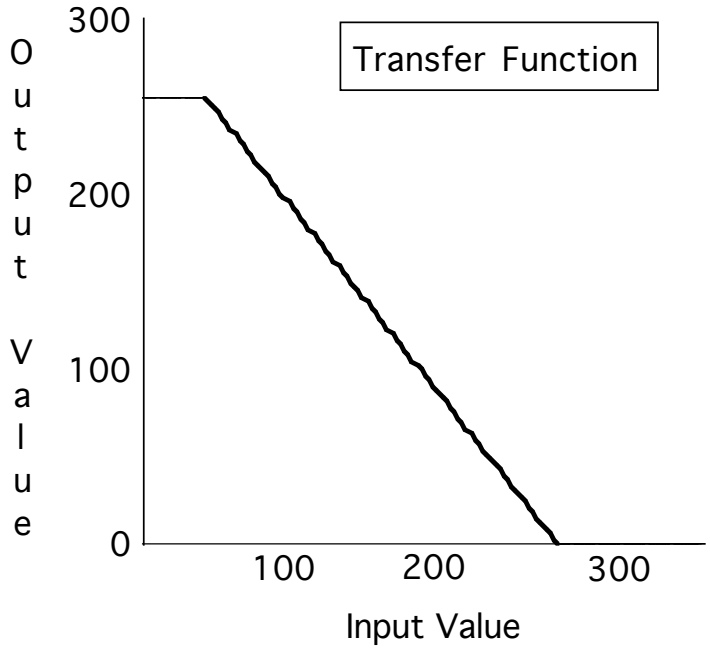
(c) [3] What is *backface culling*? How does OpenGL perform backface culling?

11. Image Analysis (CHOICE: 7 marks total)

(a) [2] What is the difference between an *ideal image* and a *digital image*?

(b) [3] Describe how to construct a filter mask for *edge detection*.

(c) [2] Suppose that you have the following transfer function. What will it do to an image?



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

(a) [1] Why do we use triangles in computer graphics?

(b) [1] What are the disadvantages of using triangles?

(c) [5] Sketch examples of how Hermite and Bézier curves are defined.

End of examination
Total pages: 13
Total marks: 70