UNIVERSITY OF DUBLIN

TRINITY COLLEGE

Faculty of Engineering, Mathematics and Science

School of Computer Science and Statistics

Trinity Term 2014

B.A.I Engineering
B.A. (Mod.) Business & Computing
B.A. (Mod) CSLL

CS4052 – Computer Graphics

Friday, 2nd May 2014 **GMB** **14:00 – 16:00**

Dr. Rachel McDonnell

Instructions to Candidates:

Answer any FOUR questions – 25 marks each.
All questions carry equal marks.

Please use a **separate answer book** for each question.
The entire question paper must be handed in at the end of the examination.

Question 1

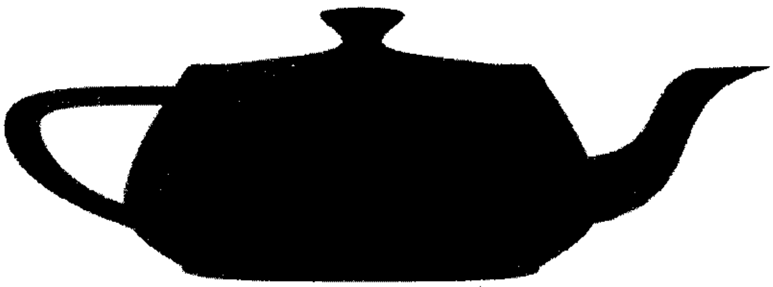
(a)	Compare and contrast the Gouraud and Phong shading algorithms. Which handles specular reflection better?	(5 Marks)
(b)	i. Define the full Phong Illumination model and explain each of the terms. ii. Write a vertex and fragment shader in GLSL (or equivalent shader language) to colour an object using the full Phong Illumination model.	(10 Marks) (10 Marks)

Question 2

(a)	Given the following vertex shader, determine what you would expect a rectangular flat planar object to look like, if it was rendered using this vertex shader. Assume that the plane is tessellated to contain at least 5 vertices wide and 4 vertices high. Also, assume that the plane lies on the x-z axis.
	
	`in vec3 vp;`
	`uniform mat4 proj_mat, view_mat, model_mat;`
	`uniform float time;`
	
	`void main(){`
	`  vec3 pos = vp;`
	`pos.y = sin (6.28 * -pos.x + time * 0.005) * 0.125;`
	`gl_Position = proj_mat * view_mat * model_mat * vec4 (pos, 1.0);`
	`}`
		(10 Marks)

(b)	Provide an outline of the basic ray-tracing algorithm. You are encouraged to use pseudocode and drawings to illustrate its operation.	(15 Marks)

Question 3

(a)	Explain the following terms: i. Isometric projection ii. View frustrum	(5 Marks)
(b)	Given the image below, provide the modern shader-based OpenGL application code and shaders to show how this image could be created. Assume that we have already loaded a vertex buffer object with the necessary vertex data for a regular teapot object, and have enabled and bound that buffer. Also, assume that you have access to functions to rotate, translate, and do perspective and orthographic projections on 4 x 4 matrices. 	(10 Marks)
(c)	Describe the process for transforming a vertex using a perspective projection. Use diagrams and equations where appropriate.	(10 Marks)

Question 4

(a)	Distinguish between the implicit and parametric representations of an object, and discuss their relative merits.	(5 Marks)
(b)	Explain how Bezier curves are related to Hermite curves, and derive the change of basis matrix from Hermite to Bezier.	(10 Marks)
(c)	Explain each of the following in the context of Parametric Cubic curves, giving example matrices where appropriate. i. Curve Continuity ii. Geometric and parametric continuity iii. Geometry matrix iv. Basis Matrix v. Blending functions	(10 Marks)

Question 5

(a)	Show using a diagram how changing basis is geometrically equivalent to transformation. Use the example of the $t = \begin{bmatrix} 0\cdot5 \\ 0\cdot7 \\ 0\cdot5 \end{bmatrix}$ vector **t** with respect to **xyz.**	(5 Marks)
(b)	Provide OpenGL code (or similar Graphics API) to create a virtual hand with a lower arm, wrist, and three fingers, each with two segments. Assume you have access to functions to `drawArm()`, `drawWrist()`, and `drawFingerSegment();` i. Write the necessary code to animate a slow clockwise rotation of the wrist (using a right handed system) ii. Write the necessary code to animate the motion of the fingers as if flexing (bending at the knuckle) one by one (using a right handed system)	(10 Marks) (5 Marks) (5 Marks)

Question 6

(a)	Explain how transformations can be composed. Illustrate your answer by showing how a shear by θ along the y-axis of an object centred at some arbitrary point C = (cx, cy, cz), can be achieved by composition of rotation and scale. The object should remain centred about C after the shear. Provide the OpenGL code that would achieve this transformation.	(10 Marks)
(b)	Describe each of the steps of the programmable 3D graphics pipeline.	(15 Marks)