Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

Faculty of Engineering, Mathematics and Science

School of Computer Science & Statistics

Integrated Computer Science
Integrated Engineering
BA (Mod) Computer Science and Business
BA (Mod) Computer Science and Language
Year 4 Annual Examinations

Hilary Term 2018

CS4052 – Computer Graphics

11 January 2018 **Goldsmith Hall** **14.00-16.00**

Prof 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: Mapping

(a)	i. Normal mapping is used to fake detail on an object. Describe how this is achieved, using diagrams where appropriate. ii. Name one drawback of normal mapping and what can be used to overcome it.	(10 Marks)
(b)	A texture map is an image applied to the surface of a polygon, which allows a simple object to appear much more complex. One drawback is that it is often the case that a rendered pixel on the screen will be of different resolution from the pixels in the texture map image. For example, a single screen pixel may actually cover multiple texture map pixels, when the object being projected to that pixel is far from the camera. Or, a single screen pixel may be much smaller than a texture map pixel when the object is close to the camera. Both of these situations lead to problems in the resulting texture mapped image. Explain what the artifacts will look like in both cases, and give descriptions of techniques that could be used to minimize the artifacts.	(10 Marks)
(c)	What is environment mapping and what objects does it work best on and why?	(5 Marks)

Question 2: Graphics Pipeline & Shaders

(a)	Describe each of the steps of the geometry stage of the programmable 3D graphics pipeline.	(15 Marks)

(c)	Given the following fragment shader, determine what you would expect a teapot object to look like, if it was rendered using this fragment shader. Discuss your reasoning.
	
	`uniform vec3 lightDir;`
	`varying vec3 normal;`
	
	`void main()`
	`{`
	`  float intensity;`
	`  vec4 colour;`
	`  intensity = dot(lightDir,normalize(normal));`
	
	`  if (intensity > 0.95)`
	`  colour = vec4(1.0,0.5,0.5,1.0);`
	`  else if (intensity > 0.5)`
	`  colour = vec4(0.6,0.3,0.3,1.0);`
	`  else if (intensity > 0.25)`
	`  colour = vec4(0.4,0.2,0.2,1.0);`
	`  else`
	`  colour = vec4(0.2,0.1,0.1,1.0);`
	`  gl_FragColor = colour;`
	
	`}`
		(10 Marks)

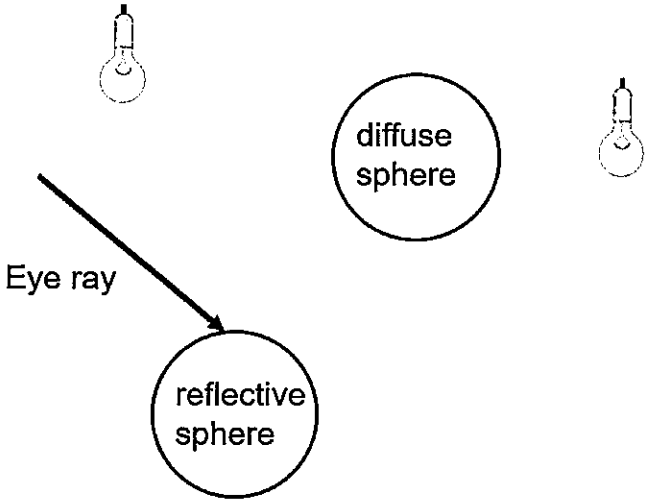
Question 3: Transformations

(a)	An object is located at an arbitrary location in the 3D space. Explain the sequence of operations necessary to rotate it around an arbitrary axis, defined by the points P and Q. Provide a figure (with labels, angles, etc.) that illustrates your answer.	(15 Marks)
(b)	Assume that you have a triangle in object space with vertices: (1, 0, 0), (0, 1, 0) and (0, 0, 1). The triangle undergoes the following transformations in order to move to world space. (a) Scaling along the x axis and y axis by 2 (b) Rotation about the z axis by 90 degrees (c) Translation by the vector (3, 2, 1) Give the modelling transformation matrix (as a single matrix) and calculate the positions of the three vertices in world space.	(10 Marks)

Question 4: Illumination

(a)	Explain the following terms: i. Flux ii. Radiosity iii. Radiance	(3 Marks)
(b)	Compare and contrast the Gouraud and Phong shading algorithms. Which handles specular highlights better? Explain where the calculations for Gouraud and Phong shading should be performed when using modern shader-based OpenGL.	(7 Marks)
(c)	Explain each of the following with respect to illumination models (using diagrams and equations where appropriate): i. The Inverse Square Law ii. The Cosine Rule iii. BRDF (include examples)	(15 Marks)

Question 5: Miscellaneous

(a)	Explain how a depth buffer (z-buffer) works	(5 Marks)
(b)	The following scene that we wish to ray-trace has a reflective sphere, diffuse sphere, and two lights. Sketch the scene in your answer book and, starting from the eye ray, draw all additional reflection, refraction, and shadow rays needed to compute the colour of the eye ray.  	(5 Marks)
(c)	You are working on an underwater scene in a movie with a school of virtual fish and a virtual deep-sea diver is swimming with them. You have been asked to animate the scene as realistically as possible. Briefly describe each of the techniques below and what part of the animation they could be used for. 1. Optical motion capture 2. Blendshape animation 3. Behavioural animation 4. Physically-based animation 5. Keyframing	(15 Marks)