UNIVERSITY OF MALTA

FACULTY OF INFORMATION COMMUNICATION TECHNOLOGY

DEPARTMENT OF COMPUTER SCIENCE

B.Sc. (Hons.) ICT Year II

May/June 2010 Assesment Session

CSA 2207: Computer Graphics I **14th June 2010**

09:15 - 11:15

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*Answer **any four** questions. Be sure to provide* **adequate exemplification** *to illustrate your understanding of concepts discussed even if not explicitly asked to do so.*

1. (a) In real-time rendering, the graphics **rendering pipeline** is of central importance. Discuss its main operations by describing the flow of data (and how this is transformed) from the start to the end of the pipeline.
[10 marks]

   (b) Write down short notes on the following:

   (i) Virtual Camera;

   (ii) Coordinate System and 3D Objects;

   (iii) Light Sources;

   (iv) Shading Equations;

   (v) Rasterisation.

[10 marks]

   (c) What is the role of a game engine? Include in your answer a description of a typical game engine loop.
[5 marks]

2. (a) Assuming Euclidean Space, given two points A = [10,4,6] and B=[3,1,-2], what direction vector should one follow to move from A to B
[1 mark]

(b) What does the norm of a vector give us? How is this norm used to normalise a vector?

[2 marks]

(c) A very important operation on vectors in CG is the dot product. How is the dot product of two vectors u and v computed?

[2 marks]

(d) How is the dot product related to the angle between two vectors?

[3 marks]

(e) Describe an orthonormal basis. Is the standard basis used in CG orthonomral?

[4 marks]

(f) Another important operation on vectors is the cross product. How is this operation used in CG?

[4 marks]

(g) Write short notes on the following:

(i) Identity Matrix;

(ii) Transpose of a Matrix;

(iii) Inverse of a Matrix

[9 marks]

3. (a) The rotation and scaling transformations are referred to as Linear Transformations, whereas translation is not. What does this mean? How are linear and non-linear transformations put together in a single matrix?

[4 marks]

(b) Given that the multiplication operator on matrices in non-commutative, the order in which transformations are carried out becomes important. Consider the four 2D vertices A,B,C and D with vertex positions [-1, 1], [1, 1], [-1, -1], [1, -1]. Draw the transformations R(S(p)) and S(R(p)) where R is a rotation transformation of 45° around the origin on the XY plane and S is a non-uniform scaling transformation of 2 units along the y-axis and 4 units along the x-axis.

[4 marks]

(b) Assume you are given three models S, E and M represeting the Sun, the Earth and the Moon. What matrix transformations would you apply on the three different models in order to simulate a Sun-Earth-Moon system (i.e. Moon orbiting the Earth. Moon+Earth orbiting the Sun).

[11 marks]

(c) Define a Rigid Body Transform.

[3 marks]

(d) When transforming the vertices of a 3D model one would also want to transform the normals associated with these vertices. What problems might arise when the same transformation matrix (as used for the vertices) is used for the normal?

[3 marks]

4. (a) Primitives consititute the building blocks of geometries (3D meshes). Write short notes (with examples of) describing the following primitives:

   i) Line, Line Strip and Line Loop;

   ii) Triangle;

   iii) Triangle Strips and Fans;

   iv) Quads.

[4 marks]

(b) More complex shapes can be defined procedurally through the use of simpler primitives. Using the point primitive and any necessary transformations define a procedure which draws a torus.

[6 marks]

(c) Both Vertex and Index Buffers have become important objects used during rendering. Describe how these are used by providing an appropriate example.

[5 marks]

(d) Almost all virtual world environments are created using both a terrain generator and a skybox (or dome) amongst other things. Describe one technique which can be used for creating a terrain and other one for creating a skybox (or dome).

[6 marks]

(e) What is a Sprite and how is this used to create 2D games and animations?

[4 marks]

5. (a) Rendering authenticity can be increased via two general components: Geometry Detail and Illumination Modelling. Moreover for Illumination models we need to come with a realistic surface model and lighting models. Explain this statement.

[4 marks]

(b) Distinguish between Local and Global Illumination models.

[2 marks]

(c) Explain using diagrams the difference betweeh the specular and the diffuse components of lighting.

[4 marks]

(d) What is the difference between per-primitive, per-vertex and per-pixel shading?

[3 marks]

(e) The following code describes a Lambertian Diffuse Pixel shader in HLSL. Describe how the shader is working.

[5 marks]

```
Ps_Outputps_out;
float3 normal = normalize(IN.norm);
float3 lightVec= normalize(IN.lightVec);
float diffuse = saturate(dot(normal, lightVec));
ps_out.color= float4(1, 1, 1, 1) * diffuse;
return ps_out;
```

(f) Describe how the Phong Lighting model works. Use diagrams to better explain how light calculations are carried out.

[5 marks]

(g) Illustrate the difference between the Phong and the Blinn-Phong lighting models.

[2 marks]

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