FACULTY OF SCIENCE

ACADEMY OF COMPUTER SCIENCE AND SOFTWARE ENGINEERING

MODULE	**GRAPHICS** IT18X77
CAMPUS	AUCKLAND PARK CAMPUS (APK)
FSAO SSA	JULY
DATE: 2020-07	**SESSION:** Morning
ASSESSOR(S):	**MR. A. MAGANLAL**
MODERATOR:	**DR. D VOGTS (NMU)**
DURATION: 120 MINUTES	**MARKS:** 100

Please read the following instructions carefully:

1. Answer **all** the questions.
2. Answer questions in order.
3. Answer only in the answer sheets provided.
4. Use diagrams where necessary to assist in your explanations.
5. Non-programmable calculators are allowed.
6. Round final answers to three decimal places.
7. Write *cleanly* and *legibly*.
8. This paper contains **6** question(s).
9. This paper consists of **2** page(s).

QUESTION 1: Rotation Calculation

Answer only one part. Either **Matrix** or **Quaternion**

(a) **Matrix**

Construct a matrix to rotate 347° (clockwise) around the axis specified by

$$(-11, 6, 22) \quad \rightarrow \quad (-3, 0, 17)$$

Rotate the point (22, 0, 3) around this axis.

(b) **Quaternion**

Construct a quaternion to rotate 347° (clockwise) about the axis (8, –6, –5).
Use the quaternion to rotate (33, –6, –19) around this axis.

Total: 15

QUESTION 2: Lighting Equation

Write down the Phong lighting equation for a single colour light source and object (black and white model). Now calculate the viewed intensity of a point on an object given the following attributes:

- The object is not emissive at all.
- The ambient light intensity is 0.214.
- The object has an ambient coefficient of 0.936.
- The object has a diffuse reflection coefficient of 0.745.
- The object has a specular reflection coefficient of 0.996.
- The shininess (specular highlight) factor is 3.
- The intensity of the incoming light (both specular and diffuse) is 0.401.
- The point we are considering is (4, –11, –6).
- The normal at the surface is (–0.624242, 0.780303, 0.0380749).
- The light is positioned at (1, –8, 12).
- The viewer is positioned at (–6, 2, 16).

Total: 15

QUESTION 3: Proof

(a) **Provide** the *formula* for a ***Bézier curve of degree three (3)*** **[05]**

(b) **Show** that a ***Bézier curve of degree three (3)*** is affine invariant. **[10]**

Total: 15

QUESTION 4: Ray Tracing Intersection

(a) Describe how to calculate the intersection point between a ray described by $\mathbf{o} + t\mathbf{d}$ (where $\mathbf{d}$ is a unit vector) and a sphere described by $(x - c_x)^2 + (y - c_y)^2 + (z - c_z)^2 = r^2$. **[08]**

(b) How will you determine if the ray is entering or exiting the sphere? **[02]**

Total: 10

QUESTION 5: Rasterisation vs Ray Tracing

Discuss how ***forward shading rasterisation*** and ***naive recursive ray tracing*** *differ* in terms of application of realistic lighting. Your discussion should include how *visibility* is calculated, how reflection/refraction is computed and the relative speed of the technique.

Total: 20

QUESTION 6: Application

A still image of an *theater stage* is to be rendered. The stage is lit by an array of spot lights, directly above the stage. Rasterisation was selected as a method for rendering the scene. Answer the questions that follow:

(a) **Provide** a *definition* for ***global lighting model***. **[05]**

(b) **Discuss** how ***radiosity*** works. Your discussion must include details of patches, form factors and methods for solving radiosity as well as how radiosity can be integrated into the rasterisation process. **[15]**

(c) **Discuss** why ***radiosity*** should be used to render the scene as opposed to ***photon mapping***. **[05]**

Total: 25

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