Write Student ID Number Here:

Two hours

QUESTION PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Graphics

Date: Thursday 22nd May 2008 Time: 09:45 – 11:45

The Paper is in THREE SECTIONS

SECTION A is compulsory.

SECTION A must be answered on the Question Paper

Only answers written in the boxes on the Question Paper will be marked

You should also answer ONE question from Section B
and ONE question from Section C

Answer EACH of SECTIONS B and C in a new book.
Each Section is worth 20 marks

All question papers to be returned

The use of electronic calculators is not permitted.
SECTION A

Answer SECTION A on this Question Paper. The Question Paper must be returned before you leave the examination.

Each question has exactly one correct answer, and should be answered by clearly writing the appropriate letter (A, B, C, or D) in the box provided.

Each question is worth 1 mark.

This MCQ Section cannot be published
Section B

B1. Note: it is essential that you illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.

a) Explain what is meant by the term “colour model”, and describe two colour models with which you are familiar. (4 marks)

b) What is meant by the terms “additive” and “subtractive” when referring to methods of colour mixing? (2 marks)

c) Illustrating your answer with a real-world example for each, describe when it is appropriate to use GIF to encode an image, and when it is appropriate to use JPEG. (4 marks)

d) Explain how the JPEG image encoding/decoding algorithm operates (you need not include mathematical details.) (8 marks)

e) Why do JPEG-encoded images sometimes display “artefacts”, and what can be done to avoid this happening? (2 marks)

B2. Note: it is essential that you illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.

a) What is meant by the concept of “duality” between modelling transformations and camera transformations? (4 marks)

b) What transformations would you apply to an object at (0,0,0), in order to simulate the effects of that object being viewed by a camera located at (1,0,1)? (4 marks)

c) Explain what is meant by the following terms, and, for each, derive their matrix representations:

i) Orthographic parallel projection onto the z=0 plane (4 marks)

ii) 1-point perspective projection onto the z=d plane (4 marks)

d) What is a “view volume”, and why is it a useful concept? (2 marks)

e) Why is it convenient to retain the z-coordinate of a vertex after its projection, and how is this retention achieved in OpenGL? (2 marks)
Section C

C1. Note: it is essential that you illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.

Your task is to model the 2D robot shown below. The whole robot can move horizontally, controlled by translation transformation $T_1$. The identical items marked $W$ are not wheels, but part of a magnetic levitation system, and they do not rotate. Lower arm $B$ can rotate by angle $p$ (controlled by transformation $T_2$) about the point $P_A$ on $A$. Upper arm $C$ can rotate by angle $q$ (controlled by transformation $T_3$) about the point $P_B$ on $B$.

Answer this question by referring to this model.

![Diagram of the robot model with labeled parts and transformation angles]

a) What is meant by the terms “master” and “instance”? (2 marks)

b) What is a scene graph and why is it useful for modelling? (2 marks)

c) What is meant by “traversing” a scene graph? (2 marks)

d) Suggest a suitable scene graph for modelling the structure of the robot. (4 marks)

e) Explain how you would incorporate transformations into your scene graph, such that the parts of the robot can move as desired, by changing the values of the transformations in the scene graph. (4 marks)

f) You are now required to publish the robot model on the Web, and provide a mechanism for people to interactively view it and manipulate the transformations. Suggest a suitable software technology for doing this, and describe how it would work (you need not go into programming detail, just explain the ideas). (4 marks)

(Question C1 continues on the following page)
(Question C1 continues from the previous page)

g) The part \( W \), although it looks simple, actually contains several thousand sub-parts. If you were implementing this robot model in OpenGL, suggest a mechanism for efficiently representing the 3 repeating occurrences of \( W \) in the model. (2 marks)

C2. **Note: it is essential that you illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.**

a) Derive a formulation for a simple local illumination model which computes the illumination at a vertex, taking into account the following factors. Take care to define all terms and vectors you use.

- ambient coloured light
- diffuse reflection from a coloured light source at a given position
- specular reflection from a coloured light source at a given position

(8 marks)

b) Comment on the accuracy of the specular highlights that your simple model generates. Will they be physically realistic for all types of surface? (2 marks)

c) Describe a method for using your model to compute the illumination for every pixel in a triangle whose vertices are known, and which ensures that specular highlights are correctly rendered. (6 marks)

d) How would you modify the method you described in (c) to modify a pixel’s colour with an appropriate colour taken from a texture image? (4 marks)

END OF EXAMINATION