

Two hours

QUESTION PAPER MUST NOT BE REMOVED FROM THE EXAM ROOM

**UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE**

Computer Graphics and Image Processing

Date: Wednesday 23rd May 2012

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**

Use a SEPARATE answerbook for each of Section B and Section C

Each Section is worth 20 marks

**For full marks your answers should be concise as well as accurate.
Marks will be awarded for reasoning and method as well as being correct.**

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are
not programmable and do not store text.

*Section A is
restricted and
cannot be
published*

Section B

Answer *one* question from this Section.

1. Note: You are expected to illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.
 - a) Why do we use 4x4 matrices to represent transformations in 3D space?
(2 marks)
 - b) What is the role of the “modelview matrix” in the OpenGL viewing pipeline?
(4 marks)
 - c) How does the programmer control the value of the modelview matrix?
(2 marks)
 - d) What is the purpose of the OpenGL “matrix stack”? Illustrate your answer with a practical example of its use.
(4 marks)
 - e) Explain how to use a sequence of transformations in order to rotate a 3D object about a 3D vector V which does not pass through the origin. Illustrate your answer clearly with a series of sketches.
(8 marks)

2. Note: You are expected to illustrate your answers to each part of this question, where appropriate, with clearly-drawn diagrams and sketches.
- a) Explain the distinction between the activities of “modelling” and “rendering”, in Computer Graphics. (2 marks)
 - b) Derive an mathematical expression which enables the computation of the intensity of light reflected from a surface illuminated by a single point monochromatic light source. Illustrate your answer with sketches, and take care to define any symbols and vectors you use, and state the numerical ranges of values where appropriate. Your expression should include the following features:
 - i) an ambient component (3 marks)
 - ii) diffuse reflection (5 marks)
 - iii) specular reflection (5 marks)
 - c) How would you extend your model to include a coloured light source? (2 marks)
 - d) Describe the technique pioneered by Gouraud, which enables a set of triangles to be rendered with the appearance of a smooth surface. (3 marks)

Section C

Answer *one* question from this Section

3. A greyscale image can be converted to a binary (two level) image by thresholding.
- a) Define the operation of thresholding. (2 marks)
 - b) The single variable involved in this operation is the threshold. Give three methods of calculating a value of the threshold. (6 marks)
 - c) What problems arise with this operation if the brightness of the image varies across the image? How could these be corrected? (4 marks)
 - d) The Canadian Government uses aerial photographs to estimate the number of seals in the Arctic. Outline an algorithm for performing this task automatically. You may assume that the image has dark seals lying on white snow or ice. (8 marks)

4. Answer all parts.

- a) Explain the concept of convolution as it is used in image processing. Ensure that you define all the terms you use. Give a simple interpretation of the meaning of the result. (6 marks)
- b) Describe three distinct examples of the use of convolution. (6 marks)
- c) You are to design software to make motorway driving safer by providing drivers with a warning when they are too close to the car in front. Assume that the hardware and software have been developed and that you are provided with an image of the roadway in front of the car.
- i) Why would convolution be an appropriate solution to this problem? (2 marks)
- ii) Define a template for detecting all vehicles. (2 marks)
- iii) Discuss whether your solution will generate results that are consistent:
- for all vehicles
 - for vehicles at all distances from the camera
 - at all times of day and night
- (2 marks)
- iv) Describe how you would modify your system to improve its behaviour. (2 marks)